Chapter 3

PROCEDURES

3.1. Introduction

Chapter 2 concluded that averting expenditure measures are useful in estimating willingness to pay for and willingness to accept changes in environmental quality. This chapter contains a description of the methods used to empirically measure averting expenditures, including a description of the study sites. The empirical analyses will then be described. These analyses will provide information on the magnitude of household averting expenditures and the factors influencing these expenditures levels, especially perceptions of drinking water contaminant risks.

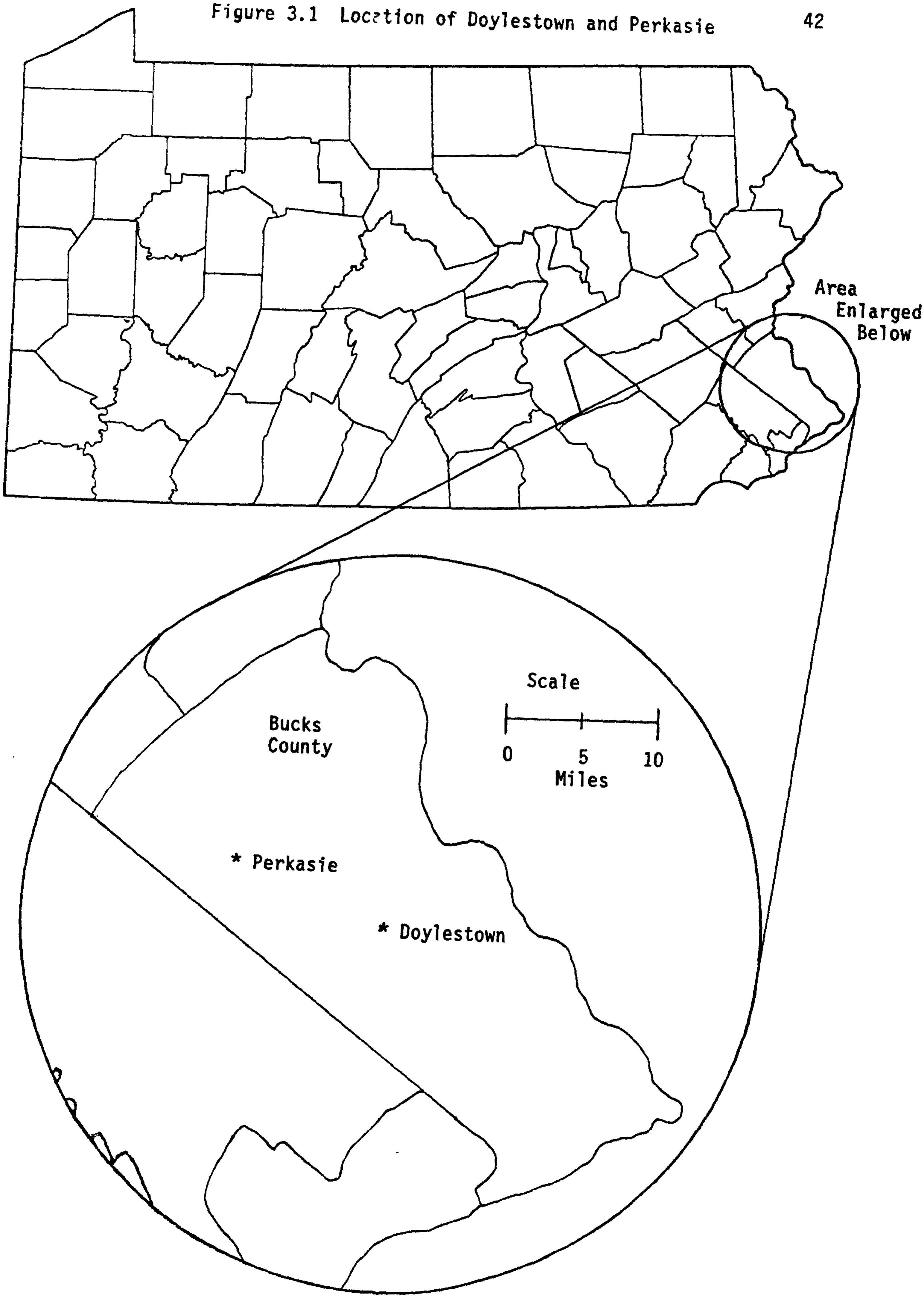
3.2. Description of Study Sites

This study examined a community which was experiencing a water contamination incident and, for a comparison, one that was not. In the Spring of 1989 several sources, including the Pennsylvania Department of Environmental Resources (DER) and the division of the Environmental Protection Agency (EPA) responsible for the National Pesticide Survey, were contacted to obtain an inventory of Pennsylvania communities that had maximum contaminant level (MCL) violations. From DER data, approximately one dozen communities were found to exceed the MCL for at least one volatile organic chemical (VOC). Each community was contacted by phone to obtain more detailed information about their situation, such as the population affected and public notification. Most of the communities removed the contaminated well from service shortly after the VOC was discovered and were able to meet water demand with remaining wells.

The study focused on communities with a public water source and excluded communities with private wells. By studying a community with a public water source, the water is likely to be of similar quality throughout the community. The results from studying a community without a public water source would be more difficult to interpret since the water may be of differing quality due to the presence of many private wells. A minimum population of 500 households was chosen to obtain a sample from a community with a public water source. Another criterion was that the contamination incident should continue during the entire study period. The likely duration of the contamination incident was determined by contact with the DER or local health agency.

The borough of Perkasie, located in Bucks County, Pennsylvania, was chosen as an example of a community that was affected by water contamination. A map indicating the location of Perkasie is given in Figure 3.1. The population of Perkasie was 5241 according to the 1980 census (Rand McNally, 1990). The borough's municipal water is supplied by the Perkasie Borough Water Authority. Perkasie has approximately 2700

Figure 3.1 Location of Doylestown and Perkasie



residential water connections. In late 1987, trichloroethylene (TCE) was found in water tested by the DER. TCE is a volatile organic chemical which can enter groundwater from industrial and agricultural sources and can cause adverse short-term and long-term health affects, including cancer (PA DER, 1986).

The maximum contaminant level established by the U.S. EPA for TCE is 5 parts per billion. Levels of TCE were as high as 35 parts per billion southern Perkasie. No temporary solution was available to reduce TCE levels below the MCL. The Water Authority, as required by DER, notified its customers of the TCE situation in a newsletter in June 1988. Customers were also told the levels of TCE could be reduced by boiling water before use. A January 1989 newsletter informed residents that TCE was still present in the borough water supply and the problem was expected to be resolved in the next few months. A copy of this letter is given in Appendix B. However, when the questionnaire was mailed in September, 1989, the DER indicated that the problem was likely to remain until Spring of 1990.

The borough of Doylestown, also located in Bucks County, Pennsylvania, was chosen as a community that had not experienced any recent water supply problems. The location of Doylestown is also shown in Figure 3.1. The borough has over 2,900 residential water connections serviced by the Doylestown Water Works. Doylestown is located about 15 miles from Perkasie and population was 8717 according to the 1980 census (Rand McNally, 1990). TCE was detected in one well in 1986 but that well was taken out of service and sufficient water was obtained from remaining wells. This received little publicity and since that time the water supply has had no further MCL violations.

There are several reasons for studying a community with no contamination problems. First, comparisons between the two communities will be useful in several aspects, including risk perceptions, attitudes towards state and local governments and future expectations concerning the quality of the water supply. Campbell and Stanley (1966) indicated that improved validity of results can be obtained when a “control group” is studied. A control group is defined as a sample or population which has not experienced the factor under study. In this situation, one group has experienced water contamination and another has not. The difference between the control group and the experiment group is assumed to be due to the factor under study. To determine if Perkasie and Doylestown residents have similar attitudes towards water contamination, questions were asked about risk perceptions and averting actions related to water use. A community with water contamination problems is not likely to be representative in its views and attitudes towards drinking water risks since most communities have not experienced such problems. A water contamination incident may increase awareness and concern over water quality issues. As a control group, Doylestown would be representative of risk attitudes and averting expenditures in Perkasie prior to TCE contamination. Data from the two communities will be compared to determine if Doylestown is an appropriate control group for Perkasie.

3.3. Data Collection

Mail questionnaires were chosen as the instrument to elicit information concerning individual's averting behaviors, risk perceptions and demographic factors. The instrument was chosen due to cost considerations. Time, personnel and other resources were not available to conduct personal telephone interviews for the total sample of nearly 4000 households in the two communities. Data collection through telephone interviews may result in higher response rates and more complete information than mail questionnaires (Dillman, 1978). However, a high response rate (70%) was achieved in the pilot study using mail questionnaires (Abdalla, 1989) and mail questionnaires have been used in several previous studies of the value of environmental factors (Menz and Mullen, 1981; Barrington, Krupnick and Spofford, 1986).

A mailing list of over 3,200 Perkasie residents was obtained from the Perkasie Borough Office's list of electricity-bill payers since a mailing list could not be obtained from the Perkasie Borough Water Authority office. Businesses were excluded from the mailing list since only information concerning household averting expenditures was desired. A representative sample size was determined based on a procedure described by Kalton (1983). The formula below is indicated by Kalton to obtain results which are within 2% of the population distribution with 95% confidence. In other words, the 95% confidence interval of the population mean is defined as plus or minus 2% of the sample mean by:

$$n' = [(1.96*1.96)(PQ)]/(2*2) \qquad (1)$$

where n' is an initial estimate of the sample size, P is the population percentage to be sampled and Q is defined as (100-P).

Obviously, (PQ) is maximized when P=Q=50 percent. Kalton indicates that 30 percent is a relatively conservative estimate of P. Then, n' is:

$$n' = [(1.96*1.96)(30*70)]/(2*2) = 2017. \qquad (2)$$

Since this sample size is relatively large compared to the effective population size of 2602, Kalton suggests the following calculation to revise the sample size :

$$n = Nn'/(N+n') \qquad (3)$$

where n is the revised sample size and N is the population size. The revised sample size is thus:

$$n = (2602*2017)/(2602+2017) = 1136. \qquad (4)$$

Consideration must also be given to the expected response rate of the survey. Assuming a response rate of 60%, 1893 surveys should be mailed. To simplify the sampling procedure, an approximation of this value was to choose a two-thirds sample of 1733. The sample was chosen by deleting every third entry from the mailing list.

A mailing list for Doylestown was obtained from the Doylestown Borough Office. This list included all residential and business water connections. The business connections were excluded from the sample. In a manner similar to the procedure for the Perkasie sample, a two-thirds sample was considered appropriate to obtain representative results. The sample was obtained by deleting every third entry from the mailing list and included 1558 households.

The survey process was similar to that suggested in Dillman (1978). The initial mailing included a copy of the questionnaire, a cover letter introducing the project and encouraging response and a self-addressed return envelope with prepaid postage. A copy of the cover letter and questionnaire sent to Doylestown residents is presented in Appendix C. A copy of the cover letter and questionnaire sent to Perkasie residents is given in Appendix D. One week after the initial mailing, a reminder postcard was sent to the entire sample which thanked those that had returned the questionnaire and asked those that had not returned it to do so. A copy of this postcard is given in Appendix E. Two weeks after the postcard, a mailing was sent to only those households which had not yet returned the questionnaire. This included another copy of the questionnaire, a cover letter and return envelope. Finally, a fourth mailing was sent five weeks after the postcard to households which had still not returned a questionnaire. The contents of this mailing were similar to that used in the third mailing.

3.4. Analytical Methods

Information obtained from the mail questionnaires was used to calculate averting expenditures for each household. The change in averting expenditures resulting from the Perkasie TCE contamination was determined by isolating costs indicated to be a direct response to the contamination. For Doylestown residents, a value was established for household averting expenditures. Summing Perkasie household averting expenditures for all respondents and extrapolating to the community population, an estimate of total averting expenditures resulting from the TCE contamination was estimated.

The validity of the Doylestown sample as a control group was tested by comparing the distributions of demographic and risk variables. If Doylestown is a valid control group, the averting expenditure levels in Doylestown can be considered an acceptable approximation of the averting expenditures in Perkasie without the TCE contamination.

Descriptive statistics will be presented for both communities and compared to test the validity of Doylestown as a control group. Regression analyses will be performed to explain averting behavior levels. This will be done for both communities and the results can be compared. Since the dependent variable is continuous, ordinary least-squares can be applied as the regression technique. Ordinary least-squares was chosen as the regression procedure, as opposed to other methods such as factor analysis or two-stage least-squares, since strong hypotheses for the relationships between the dependent and independent variables do not exist in previous studies.

3.5. Variable Descriptions

3.5.1. Dependent Variables

The dependent variable differs in the two survey sites. Since the Doylestown site does not involve a change in water quality, the dependent variable is the total dollar value of household averting expenditures. The dependent variable for the Doylestown situation is referred to as DOY_EXP. The Perkasie site did involve a change in water quality so the calculation of a change in household averting expenditures as a result of contamination was possible. In this situation, the dependent variable is the estimated dollar value of the change in averting expenditures. The dependent variable will be referred to as PER_EXP and will be calculated as the additional household averting expenditures as a direct result of the TCE contamination.

Household averting expenditures can be estimated from the survey data. The total expenditures will be the sum of the costs of bottled water, boiling water, purchasing home filtration systems and hauling water. The costs due to purchasing and installing a home filtration system are taken directly from the survey. The cost of bottled water can be inferred by obtaining an average cost of bottled water through contacting local bottled water distributors. The costs associated with boiling water will include the time and energy cost involved. The cost of hauling water will be calculated as the sum of the travel and time expenses. Details of the estimation process are given in Chapter 4.

The definition of the dependent variable assumes that households can engage in a level of averting expenditures ranging from a dollar value of zero to any positive value. However, a certain level of averting expenditures may represent different levels of protection across households, depending on the production technology of the household. Thus, the dependent variable represents a level of averting expenditure but not necessarily a level of protection.

The dependent variables included in the regression analyses are also specified as the natural logarithm of the change in averting expenditures for the Perkasie sample and the averting expenditures for the Doylestown sample. This specification represents an alternative functional form of the model. This specification reduces the impact of individuals engaging in very costly averting behaviors, such as purchasing a home water purification system.

3.5.2. Independent Variables Included in Both Analyses

The independent variables to be considered in both regression equations are listed below with any available references to support inclusion of the variables. Also, hypothesized relationships with the dependent variable are discussed.

1. FAMILIAR: The respondent's rating of his or her familiarity with chemical substances on a linear integer scale from 1 (Not familiar at all) to 4 (Very Familiar). The direction of influence is not hypothesized since previous studies have not included such a variable and logical deductions can be made in both directions. For example, an individual who is familiar with chemical substances may practice safety measures on the job and likewise engage in household defensive measures. Another possibility is that an individual who is familiar with chemicals and has not experienced any adverse effects may believe that defensive measures are unnecessary.

2. SERIOUS: The respondent's perception of the problem of toxic chemicals in the environment on a linear scale from 1 (Not serious) to 4 (Very serious). A positive relationship is hypothesized with DOY_EXP since individuals who believed chemicals were a serious problem are expected to be more likely to engage in averting actions. No definite relationship is hypothesized with PER_EXP. Perkasie residents who believed chemicals were a serious problem in the environment may already have been taking averting actions before the TCE contamination and believed that no additional averting actions were warranted. For Perkasie residents who were not taking averting actions before the contamination and indicated that chemicals were a serious problem, the TCE contamination is hypothesized to motivate them to take defensive measures.

3. TRUSTPA: The trust in state officials to provide the facts concerning the quality of the water supply. This information is given on a scale from 1 (You can not trust them at all) to 4 (You can trust them a lot). This variable is hypothesized to relate negatively with averting expenditures since individuals who mistrust state officials are likely to believe that their water quality is worse than available information indicates and take averting measures.

4. TRUSTLOC: The trust in local officials to provide the facts concerning the quality of the water supply. The responses to this variable are the same as TRUSTPA. This variable is also hypothesized to relate negatively with averting expenditures for the same reason as TRUSTPA.

5. FUTURE: For the Doylestown sample, the probability that the respondent's water supply will be affected by any problems in the next few years. For the Perkasie sample, the probability that the water supply will be affected by additional problems in the next few years. The indexed response ranges from 1 (Very high chance) to 5 (Very low chance). This variable is hypothesized to be negatively related to the dependent variables since individuals who anticipate future water quality problems are likely to engage in averting actions as a protective measure.

6. SCHOOL: The respondent's education level, given on a scale from 1 (Never attended school) to 7 (Graduate or professional school). No hypothesis is made concerning the direction of influence of this variable.

Educated individuals may be more aware of the facts relating to water quality and possible averting actions. Whether or not this will result in more or less averting activity is not intuitively clear. However, a variable for education was included in previous averting behavior studies, such as Smith and Desvouges (1986). They concluded that increased education was likely to be associated with less averting behavior. Gerking and Stanley (1986) found that education did not significantly influence willingness-to-pay bids for improved air quality.

7. HEALTH: The respondent's indicated health, ranging on a linear scale from 1 (Very poor) to 5 (Very good). The relationship with the dependent variables is hypothesized to be negative, indicating that individuals in poor health are likely to undertake greater averting expenditures. Individuals with poor health are at a higher baseline risk to illness than those with good health. Assuming individuals with poor health value marginal health increases more than do those in good health, they would be likely to spend more on averting goods. A health variable was included in previous studies to value environmental factors. Gerking and Stanley (1986) concluded that health did not have a statistically significant effect on WTP bids for improved air quality. Shechter (1989) included a health variable in logit regression equations predicting the probability of visits to physicians but it was not indicated as statistically significant.

8. JOBRISK: The subjective rating of the risk the respondent undertakes during the duties of his or her job. This information is given on a scale from 1 (Insignificant risk) to 5 (Very serious risk). Since an individual whose occupation entails risk may be more likely to accept risks elsewhere, the hypothesized relationship between JOBRISK and the dependent variables is negative.

9. INCOME: Income was coded by defining a dummy variable for nine of the ten income categories. A dummy variable was not assigned to the first income category (Below $5,000) since that was chosen as the baseline income category. A value of 1 indicated that the respondent checked that particular income category. All dummy variables were included in the regression analysis. Statistical significance is interpreted by stating that the averting expenditures of individuals with that income category differed from those with income below $5,000. Those income variables which were statistically significant were grouped together to form another variable, indicating income above or below a certain amount. The exact specification of any income variables will be given with the regression results in Chapter 5. A positive relationship is hypothesized between INCOME and the dependent variables because higher income is likely to allow for a greater level of averting expenditures. A positive relationship between income and contingent WTP bids to avoid risk increases was found by Smith and Desvouges (1987). However, Smith and Desvouges (1986) found that income did not significantly influence the probability that individuals will engage in certain averting behaviors.

10. HOME: Whether the respondent rents or owns (or is buying) a dwelling. This is coded as a 0 if the respondent rents and a 1 if the respondent owns or is buying. The hypothesis is that a renter is not likely to invest in a

permanent home filtration system, preferring less expensive and more temporary averting behaviors. Thus, a positive relationship is expected.

11. CHILD: Whether or not any children 3 to 17 years old live in the respondent's household. This will be coded as a 0 if no such children are present and a 1 if children are present. The hypothesis is that families with children are more likely to invest in averting goods due to concern over the children's health and a positive relationship is expected. Support for this hypothesis comes from Shechter (1989), who found that physician visits, which can be considered a type of averting behavior, were more likely to occur among households with children 18 years of age or younger. Smith and Desvouges (1987), on the other hand, concluded that the number of children did not significantly influence contingent WTP bids to avoid risk increases.

12. INFANT: Whether or not any children under 3 years of age are present in the respondent's household. This will be coded as a 1 if such children are present and a 0 if no infants are present. This variable is hypothesized to be positively related to the dependent variables for reasons similar to that for CHILD. A distinction was made between CHILD and INFANT due to the conclusion of Abdalla (1989) that the presence of children under 3 years of age was an important explanatory variable of averting expenditure changes associated with a water contamination incident but children 3 to 17 years of age was not significant. Thus, while both CHILD and INFANT are expected to be positively related to the dependent variables, INFANT is hypothesized to exhibit greater explanatory power.

13. SMOKE: Whether or not the respondent smokes, coded as a 0 if the respondent does smoke and a 1 if he or she does not smoke. Individuals that smoke are assumed to be less health conscious than those who do not, so smokers are likely to spend less on averting goods as a safety measure from detrimental health effects and thus a positive relationship is hypothesized. Smith and Desvouges (1986) found that smokers were less likely to engage in purchasing water filters and bottled water to avoid exposure to tap water.

14. EXERCISE: An index of the frequency of exercise the respondent undertakes. The scale ranges from 1 (Not at all) to 5 (Five or more times per week). The hypothesis is that individuals who exercise often are more concerned about their health which may lead them to undertake averting actions related to water use. Thus, a positive relationship is expected.

15. AGE: The age of the respondent in years. The expected relationship is indeterminant since evidence does not indicate if older or younger individuals are likely to spend more on averting goods. Previous research has not found a consistent relationship between age and averting expenditures. Smith and Desvouges (1986) noted that age did not significantly influence the decision to purchase water filters or bottled water in responses to hazardous waste contamination. Also, Portney and Mullahy (1986) included age in attempting to explain restricted activity days and did not find a statistically significant relationship. Weinstein

and Quinn (1983) suggested that health decisions and willingness to accept risks may be influenced by remaining life expectancy such that older individuals are more likely to accept health risks.

16. GENDER: The gender of the respondent, coded a 0 if female and a 1 if male. A hypothesis is not given for this variable as neither previous studies nor logical analysis indicates if gender influences averting expenditures. Gerking and Stanley (1986) found that males gave lower contingent WTP bids for improved air quality than females. Portney and Mullahy (1986) included a dummy variable for gender with restricted activity days as the dependent variable and found no statistical significance. Shechter (1989), using logit regression, found that females were more likely to visit physicians. However, this may be due to different health needs and not reflective of averting behavior decisions.

17. MARRIED: Whether or not the respondent is married, coded as a 0 if not married and a 1 if married. No definite relationship is hypothesized for this variable since no strong empirical evidence of a relationship has been found in previous studies. Ostro (1983) included a dummy variable for marital status in explaining work loss as a result of air pollution but did not find conclusive statistical significance.

3.5.3. Independent Variables Included Only in the Doylestown Analysis

The following independent variables will be used only in the regression equations utilizing the Doylestown data set.

1. D_RISK: The indicated perception of the cancer risk associated with drinking water. This variable is coded on a linear integer scale from 1 (Insignificant risk) to 5 (Very serious risk). The hypothesis is that individuals perceiving a high risk of cancer from drinking water are more likely to have high levels of averting expenditures. Thus, a positive relationship with DOY_EXP is expected.

2. D_RATE: An index of the respondent's risk perception of general environmental risks obtained from question (28) in the survey. The index will be constructed by summing all nine responses to the question. Thus, the value of D_RATE will range from 9 to 45 and a higher value will indicate a higher level of risk aversion. Individuals who rate risks as more serious are hypothesized to spend more on averting goods; thus, a positive relationship is expected. Note that D_RISK is a risk rating specific to water quality and D_RATE is a general risk rating referring to environmental influences. Cropper (1981) included an index of risk aversion in considering the effect of air pollution on lost days of work but did not obtain significant results.

3. D_PROB: A dummy variable signifying awareness of any problems with the water supplied by the Doylestown Water Works. This was coded a 0 if the respondent was not aware of any problems and a 1 if the respondent was aware of at least one problem. The hypothesis is that respondents aware of

problems would consider their water to be of lesser quality than those not aware of problems. Thus, individuals who were aware of problems are expected to engage in averting behaviors and a positive relationship is anticipated.

3.5.4. Independent Variables Included Only in the Perkasie Analysis

The following variables will be included only in regression equations based on the data set from the Perkasie survey.

1. P_BEFORE The respondent's rating of the cancer risk associated with drinking the water before the presence of TCE. The scale ranges from 1 (Insignificant risk) to 5 (Very serious risk). A hypothesis concerning the direction of influence is not evident since views concerning the quality of the water before the presence of TCE may not influence averting behavior decisions made after the contamination incident became known. If prior opinions do affect averting expenditures, the relationship with PER_EXP can be hypothesized in either direction. For example, an individual who perceived the health risk as high before the TCE contamination may already have been engaging in a significant level of averting activity and decided that no further actions were necessary as a result of the contamination. However, a high value for P_BEFORE may indicate a high concern about water quality and a large increase in averting expenditures when the contamination was announced.

2. P_TCE: The qualitative rating of the cancer risk associated with the levels of TCE in the water supply. This scale also ranges from 1 (Insignificant risk) to 5 (Very serious risk). A positive relationship is expected between P_TCE and PER_EXP since individuals who perceive a high level of risk associated with the TCE contamination incident are likely to react by investing in averting behaviors.

3. P_RATE: A variable defined exactly as D_RATE. The sum of all responses to question (47) of the Perkasie survey is taken to obtain P_RATE. A positive relationship is expected since averting expenditure increases are likely to occur for individuals who rate risks as being more serious.

4. P_CANCER: An alternate specification of P BEFORE and P TCE which attempts to quantify the increase in cancer risk associated with the TCE contamination. This variable is obtained by first noting the value of P_TCE from question (48) of the survey. Then referring back to question (47), locate the numerical risk rating(s) corresponding to the qualitative response from question (48). If the qualitative risk evaluation (response to question (48)) is circled only once in question (47), then the value of P_CANCER can be read directly from the logarithmic scale, such as 1 in 10 million. If the qualitative risk evaluation is circled an odd number of times in question (47), then the midpoint will be considered the value of P_CANCER. If the response to question (48) is circled an even number of times in question (47), then the numerical average of the two middle values

will be taken as P_CANCER. For example, assume the respondent answered question (48) with a response of (Serious) and circled (4), corresponding to a (Serious) response, for values of (1 in 10,000), (1 in 1,000), (1 in 100) and (1 in 10) in question (47). Then a value of 1/550 (the midpiont of 1 in 100 and 1 in 1,000) would be assigned for P_CANCER. Note that a value of 1/550 (0.00182) would also be assigned for a respondent that answered (Serious) for only (1 in 1,000) and (1 in 100). Possible differences in risk attitudes between such responses are not defined in the available literature. The P_CANCER variable can assume values from 1 in a billion to 1/10. The hypothesized relationship between P_CANCER and PER_EXP is positive since individuals who perceive the cancer risk of TCE as high (a high value of P_CANCER) appear more likely to take specific averting actions than individuals who rate the cancer risk as low.

5. P_INFO: An index of the information the respondent received or obtained relating to the health risks of exposure to TCE and the household actions that can be taken to reduce exposure. This variable is obtained by summing the responses to questions (9) and (10) of the Perkasie survey. Thus, the value of P_INFO ranges from 2 to 8, with a higher value indicating more information received or obtained. The expected result is that individuals with more information concerning TCE are more likely to increase averting expenditures. However, this expected relationship may be reversed if the received or obtained information indicates that exposure to TCE poses little or no health threat. A similar variable was considered by Swartz and Strand (1981). They found that the amount of newspaper articles printed concerning a contamination incident positively influenced activities to avoid exposure.

6. P_OTHER: A dummy variable assigned a value of 0 if the respondent was not aware of other water problems besides the TCE contamination and a value of 1 if the respondent was aware of other water quality problems. The relationship between PER_EXP and P_OTHER can be hypothesized to be either direction. If the respondent was aware of other problems, averting actions may have been taken in response to these problems such that additional actions were not necessary due to the presence of TCE in the water. However, if no averting actions were taken in response to the other problems, the presence of TCE in the water may have been a factor which convinced individuals to take some actions.

3.6. Risk Perception and Analysis

Changes in environmental quality may affect the level of health risk imposed upon individuals. The scientific information concerning various health effects of environmental pollution are not fully understood (Slovic, 1986). Epidemiological research attempts to understand biological health effects utilizing human and animal data (Hoffman, 1989). Previous studies, such as Pitcher (1989) and Murdoch, et al. (1989), have attempted to understand the health affects associated with environmental factors.

Public perceptions of environmental health risks are often inaccurate (Liechtenstein, 1978). Eliciting information concerning attitudes towards risk presents several difficulties (Slovic, 1986). Risk perceptions may be based on past experiences, such as accidents or natural disasters, which may overemphasize the seriousness of certain risks. Likewise, “undramatic” risks that most individuals are not exposed to, such as diabetes or asthma, may be understated. Some risk topics, such as nuclear power, cause anxiety and fear resulting in a perception that the health risk is more serious than it actually is. Even if accurate scientific information is given to the public, psychological research indicates that individuals’ beliefs change slowly and only research results supporting initial beliefs may be considered accurate. Media coverage, which may be inaccurate, can also bias risk perceptions and subtle inferences can strongly affect attitudes. Other factors that influence risk perceptions include differences between types of risks, such as voluntary and involuntary, injurious and fatal, and chronic and catastrophic risks (Slovic, 1986).

An important objective of this research was to develop a better understanding of risk perceptions through improved elicitation methods. A common approach to eliciting risks in mail questionnaires is to present some form of risk ladder, such as Barrens (1987). Risk ladders require individuals to indicate their ranking of a risk on a numerical scale. Often, examples of known risks are given at certain values to assist the ability to relate to the risk. A risk ladder was utilized in the pilot study of this research (see Appendix A) and was found to be ineffective for several reasons (see Chapter 2).

The comments obtained from the pilot study indicated that presenting benchmark examples of risks is often confusing since many individuals were not aware of the risks of the listed activities. Thus, examples were excluded from the risk perception question in this study.

An innovative method to elicit risk perceptions was designed and implemented in question (28) of the Doylestown survey (see Appendix C) and question (47) of the Perkasie survey (see Appendix D). Compared to the narrow range of the pilot study’s risk ladder, this matrix presents a broad range of numerical risks. This was designed to eliminate any bias associated with a risk ladder that usually presents a more limited range of possibilities. The range in the present survey instrument, from one in a billion to one in ten, covers a range that includes almost all actual health risks. The question asks the respondent to consider increases in cancer risks, which is specific enough to focus attention on involuntary, long-term and possibly fatal health risks without confusing the respondent with excessive details.

The matrix table allows individuals to rate several risk levels, rather than a conventional approach which inquires about only one risk level. Also, the respondent’s understanding of the question and the consistency of their answers can be checked. For example, if a respondent rates a risk of (1 in a million) as more serious than a risk of (1 in 100), the assumption can be made that the question was not understood. One could then delete that observation from the analysis. Also, information can be obtained on marginal and non-marginal risk changes since such a broad range of risk levels is presented.

The data obtained on risk perceptions will be presented in Chapter 4. Several comparisons between the two communities will be made. First, qualitative perceptions of the cancer risk associated with the water of the Doylestown sample will be compared with qualitative risk perceptions of the Perkasie sample before the contamination. The mean values of both qualitative risk perceptions are hypothesized to be statistically similar with 95% confidence. The validity of the using Doylestown sample as a control group will be strengthened if this hypothesis is correct since the baseline risk perception level of both communities could be considered similar before the TCE contamination occurred in Perkasie.

The variable P_CANCER, described previously, will be analyzed to quantify perception of the risk associated with the TCE contamination in Perkasie. The quantitative risk perception will be compared with the actual level of risk (based on laboratory tests) to determine the accuracy of individuals' risk perceptions. Responses of the Doylestown sample to the risk matrix will also be presented, analyzed and compared to those of Perkasie to determine if risk perceptions are different.

The final component of the risk analysis will be to estimate the value of a statistical life associated with the TCE contamination in Perkasie. The value of a statistical life will be calculated in this research by using the following formula:

$$\text{Value of a statistical life} = (\beta * \theta) / \eta \qquad (5)$$

where β is the average value of P_CANCER such that the average risk perception of the TCE contamination is $1/\beta$, θ is the estimate of the averting expenditures associated with the contamination for the Perkasie population and η is the Perkasie population size. The obtained value of a statistical life will be compared with the values obtained by other researchers (see Table 2.1). The values for a statistical life presented in the next chapter are the first derived using the averting behavior approach.

Chapter 4

DESCRIPTIVE EMPIRICAL RESULTS

4.1. Introduction

This chapter presents the descriptive statistics for data obtained via the procedures described in Chapter 3. Averting expenditure estimates, which were demonstrated to have theoretical relevance in Chapter 2, will be calculated. Also, the congruence of individuals' risk perceptions with risk estimates based on extrapolations from laboratory studies will be explored. Lastly, the value of a statistical life will be calculated for the Perkasie sample and compared with values found by other researchers.

4.2. Response Rate of the Perkasie Survey

A total of 793 completed questionnaires were received from Perkasie residents. There were 32 questionnaires which were returned but were not valid for such reasons as the individual no longer lived in Perkasie or certain questions pertaining to awareness of TCE or to averting activities were not answered. Also, nine questionnaires were undeliverable. Thus, the effective response rate was 46.9%.

The response rate was lower than anticipated, raising the potential of a non-response bias when extrapolating the sample results to the population. Specifically, non-respondents may have been less interested or less aware of the TCE contamination and, consequently, took fewer averting actions than respondents. To determine if such a bias was present, 50 non-respondents were contacted by telephone to answer several questions concerning their knowledge of contamination and averting actions. The results of this follow-up indicated that no bias was present. The details of the comparison of the mail questionnaire results with the telephone interview results will be presented in section 4.5, after the results of the mail questionnaire have been analyzed.

4.3. Descriptive Results of Perkasie Survey

A question was asked in the survey to determine the source of the water supplied to the respondent's residence. Since the mailing list was not obtained from the Perkasie Borough Water Authority, this question identified respondents with private wells as their water source. Of the 789 individuals who answered a question concerning the source of their water, 676 respondents indicated that they were supplied by the Perkasie Borough Water Authority, 89 respondents indicated that they had a private well and 24 respondents indicated that they did not know the source of their water. Since private wells involve rather prominent equipment and require occasional maintenance, individuals were assumed to know that a private well was present. Thus, individuals who did not know the source of their water were assumed to be Perkasie water system customers.

Respondents with private wells were excluded from further analyses since they were assumed to have been unaffected by the contamination of the public system.

A total of 703 respondents answered a question concerning awareness of the TCE contamination. Over 43%, or 304 respondents, indicated that they were aware of the contamination while 56.8%, or 399 respondents, reported they were not aware of contamination.

Individuals aware of TCE contamination were asked whether they were taking any averting activities related to water use prior to becoming aware of the presence of TCE. Of the 298 individuals who answered this question, 26.2%, or 78 respondents, indicated that they were taking some measures, while 73.8%, or 220 respondents, indicated that they were not taking any actions. Of the 78 individuals who were taking some defensive measures, 67 (85.9%) were purchasing bottled water before the contamination. Thirty-three of these 67 individuals increased their bottled water purchases as a result of the TCE contamination. The average increase in bottled water purchases was 2.656 gallons per week.

Individuals who were not purchasing bottled water prior to the contamination were asked if they started buying bottled water as a result of contamination. Over 23%, or 57 individuals, indicated that they initiated bottled water purchases while 76.6% indicated that they did not. The average amount of bottled water purchased was 3.286 gallons per week.

All respondents who were aware of the TCE contamination were asked if they purchased a home water purification system due to the presence of TCE in their water. Thirty-one individuals, or 10.6% of those who answered the question, reported the purchase of such a system. The average price, including installation costs, was $422.61.

Respondents were then asked if they hauled water from an alternate source as a result of the TCE contamination. Of the 294 individuals who answered the question, only 23, or 7.8%, indicated that they did haul water. An average of 1.62 trips per week were made at an average round-trip distance of 25.83 miles. Individuals hauling water were asked how often the trip was for the sole purpose of hauling water. More than half of the respondents hauling water never made the trip for the sole purpose of hauling water (see Table 4.1).

A total of 296 respondents answered a question pertaining to whether they boiled water due to the presence of TCE. Fifty-six individuals, or 18.9%, indicated that they boiled water. The average amount boiled was 5.9 gallons per week.

4.4. Averting Expenditure Estimates of the Perkasie TCE Contamination

The costs of the Perkasie TCE contamination were divided into the following five categories:

Table 4.1 Frequency of Trips to Haul Water for the Sole Purpose of Hauling Water During Perkasie TCE Contamination

How Often the Trip Was For the Sole Purpose of Hauling Water	Frequency	Percentage
1. Never	12	52.2
2. 1/4 of the Time	5	21.7
3. 1/2 of the Time	2	8.7
4. 3/4 of the Time	1	4.3
5. Always	2	8.7
Missing Values	1	4.3
Total	23	100.0

1. Increased purchases of bottled water among households that were purchasing bottled water prior to the contamination
2. New purchases of bottled water among those households that were not purchasing bottled water prior to the contamination
3. Cost of purchasing home water purification systems
4. Cost of hauling water
5. Cost of boiling water

The methods used to estimate each cost are presented below.

The estimates represent the cost of the contamination incident up to the time that the questionnaire was first mailed, which was September, 1989. All costs represent a flow of expenditures. Respondents were asked when they first became aware of the presence of TCE in their water. This date was assumed to be when respondents initiated their averting actions. The number of weeks was calculated from the date each respondent became aware of the presence of TCE up to the first mailing of the questionnaire. Since respondents indicated the frequency of averting activities each week, the frequency of each activity was calculated from the date the respondent became aware of the contamination up to the questionnaire mailing date.

Respondents aware of the TCE contamination but who did not indicate when they first became aware were assumed to have learned of the contamination in January 1989, which was the average date for those respondents who did indicate when they became aware of the contamination. This represented 38 weeks of the indicated averting activities up to the first mailing of the questionnaire.

Further, since TCE was first detected in the Perkasie water in December of 1987, respondents who answered that they became aware of TCE before December 1987 were considered to have learned of the presence of TCE in December 1987. Thus, the maximum period a respondent was considered taking averting activities was from December 1987 to September 1989, or 88 weeks.

Also, respondents were asked if they were taking averting measures to avoid exposure to TCE at the time they completed the questionnaire. If the respondent answered that their household had discontinued indicated averting behaviors, the number of weeks the respondent was considered as taking averting actions was reduced in half.

4.4.1. Cost of Increased Purchases of Bottled Water

Several retail grocers in the Perkasie area were contacted by phone in December 1989 to determine the price of bottled water in the area affected by the TCE contamination. The average price was $0.83 per gallon. Of the 33 respondents who indicated that they increased their purchases of bottled water as a result of the contamination, 8 respondents were no longer purchasing increased amounts of bottled water at the time they completed the questionnaire. The cost of additional bottled water was calculated by multiplying the number of gallons per week respondents were purchasing by the length of time they were considered to be purchasing the water and by the cost of $0.83 per gallon. The cost of additional bottled water for all respondents who were no longer purchasing additional bottled water totaled $246.44. The cost of additional bottled water for those who were still purchasing increased amounts of bottled water at the time of questionnaire completion totaled $2,953.14. Thus, total additional purchases of bottled water due to the TCE contamination up to September 1989, was $3,199.58.

4.4.2. Cost of New Purchases of Bottled Water

Of the 57 respondents who indicated they began purchasing bottled water as a result of the TCE contamination, 26 answered that they were no longer purchasing bottled water at the time they completed the questionnaire. The same average cost of $0.83 per gallon was used to calculate the cost of new bottled water purchases. The total cost of bottled water among those respondents who were no longer purchasing bottled water was $1,717.67. The total cost of new bottled water purchases among those households which were still purchasing bottled water in September 1989, was $4,983.32. Thus, the total cost of new purchases of bottled water during the study period was estimated to be $6,700.99.

4.4.3. Cost of Home Water Purification Systems

Thirty-one respondents reported the purchase of a home water purification system to avoid exposure to TCE. The total cost of these systems was $13,100.91 and the average cost was $422.61. However, the full cost of a water purification system would be a cost of contamination if the only reason for the purchase was to avoid exposure to TCE (see explanation in section 2.10.). Since additional reasons may have influenced the decision to purchase a purification system, only part of the cost should be considered a cost of TCE contamination. In other words, part of the purchase price could be associated with removal of TCE and part associated with other benefits, such as future water protection. Since complete information about the reasons for purchasing a purification system were not elicited in this study, no attempt was made to divide the purchase price into separate components.

The useful life span of a water purification system was assumed to be ten years. The purchase price (including installation) was converted to a weekly cost by dividing the purchase price over a ten-year period (520 weeks). This weekly cost was then multiplied by the number of weeks the respondent was considered to be taking averting actions in response to TCE. Thus, even though respondents indicated they purchased purification systems to avoid exposure to TCE, additional benefits would continue for the useful life span of the system. A total of $1348.12 was calculated as the cost of water purification systems attributed to TCE contamination. This estimate is assumed to represent a lower-bound of the proportion of water purification system costs associated with contamination. Also, this figure does not include any maintenance costs that were incurred, such as regular replacement and disposal of filters.

4.4.4. Cost of Hauling Water

The cost of hauling water was divided into travel costs and lost leisure time costs. The travel cost was based on an average vehicle operational cost of $0.326 per mile in 1987 (American Motor Vehicles Manufacturers Association, 1988). Respondents indicated the round-trip distance of trips to haul water and the number of trips per week. However, since trips were not necessarily for the sole purpose of hauling water (see Table 4.1) travel costs should be discounted according to how often the trip was for the sole purpose of hauling water. If the respondent answered that the trip was always for the sole purpose of hauling water, the total travel cost was included in the estimate. If the respondent indicated that the trip was for the sole purpose of hauling water three-quarters of the time, the travel cost was multiplied by a factor of 0.8. If the respondent answered that the trip was for the sole purpose of hauling water one-half of the time, the travel cost was multiplied by 0.6. A discount factor of 0.4 was applied if the respondent made the trip for the sole purpose of hauling water one-quarter of the time. Lastly, if the respondent never made the trip for the sole purpose of hauling water, the travel cost was multiplied by 0.2. These weights were chosen to reflect a fixed cost of hauling water, even for those who never made the trip for the sole purpose of hauling water since the individual still had to take some time and incur other costs to obtain the water.

To calculate the lost leisure time cost of hauling water, the amount of time that a trip to haul water took was calculated by assuming an average travel speed of 35 miles per hour. This time was discounted, in a manner similar to the travel cost, according to how often the trip was for the sole purpose of hauling water. Similar to Abdalla (1989), a low estimate of the value of lost leisure time was defined as the minimum wage. Until December, 1989 the minimum wage was set at $3.35 per hour (U.S. Congress, 1989). An upper estimate of the value of lost leisure time was the before-tax hourly wage as estimated by the respondents. This estimate was derived by assuming the respondents' annual income was the mid-point of the income category checked in the mail questionnaire. Respondents were assumed to be paid for 2080 hours in a year to obtain an estimated hourly wage. If the respondent did not answer the income question, the average estimated hourly wage of those who did respond to the income question, $13.22 per hour, was used for the calculation.

Of the 23 respondents who hauled water in response to TCE contamination, 8 stopped this practice by the time they returned the questionnaire. The travel cost of hauling water for these households was estimated to be $675.98. The value of lost leisure was estimated, valued at the minimum wage, to total $313.37 and, valued at the estimated hourly wage, to total $2,127.73. The total cost of hauling water for households which stopped hauling water was estimated to range from $989.35 to $2,803.71.

The travel cost for households hauling water at the time they returned the survey was estimated at $1,975.80. The low estimate of lost leisure time was $630.47 and the high estimate was $4,999.65. Including the travel cost, the cost of hauling water for those households hauling water at the time of survey completion ranged from $2,606.27 to $6,975.45. Thus, the total cost of hauling water for all respondents was estimated to range from $3,595.62 to $9,779.16.

4.4.5. Cost of Boiling Water

The cost of boiling water was divided into the energy costs and lost leisure time costs. The energy cost in the Perkasie area in 1989 was 5.5 cents per kilowatt-hour. Respondents were assumed to boil one-half gallon of water at a time for 8 minutes. This includes the time necessary to bring water to a boil using an electric stove. and requires 0.35 kilowatt-hours of electricity (Abdalla, 1989).

Of the 56 respondents who reported boiling water in response to the TCE contamination, 21 were no longer boiling water at the time of questionnaire completion. For these 21 respondents the energy costs of boiling water were estimated as $174.51. Similar to the estimate of lost leisure time for hauling water, leisure time was valued at the minimum wage and estimated hourly wage. The value of lost leisure time due to boiling water was estimated to range from $1,119.98 to $6,158.88. Thus, the total cost of boiling water for those households which had stopped boiling water was estimated to range from $1,294.49 to $6,333.39

The energy cost of boiling water for households boiling water at the time the survey was completed was estimated at $431.10. The estimate of the value of lost leisure time due to boiling water ranged from $2,766.53 to $11,665.00. The total cost of boiling water for households still boiling water was estimated to range from $3,197.63 to $12,096.10. Including households which were no longer boiling water, the estimated total cost of boiling water due to the TCE contamination from December 1987 to September 1989 ranged from $4,492.12 to $18,429.49.

4.5. Comparison of Perkasie Mail Questionnaire Results with Telephone Interview Results

The possibility of a non-response bias existed due to the low response rate of the mail questionnaire. A telephone interview of a random sample of non-respondents was conducted to determine if respondents and non-respondents were alike on key attributes. A copy of the telephone interview questionnaire is included in Appendix F. Of the 50 individuals contacted, 44 indicated that their water was supplied by the Perkasie Borough Water Authority. A total of 22 of these individuals, or 50%, indicated that they were aware of TCE contamination. Of the 22 individuals that were aware of the contamination, 6 individuals, or 27.3%, said that their household changed their activities related to water use as a result of the presence of TCE in their water.

Snedecor and Cochran (1980) describe the appropriate statistical test to compare the binomial probabilities for samples of different sizes. They define the number of observations in the first sample as η_1 and the number of observations in the second sample as η_2. The probability that a certain answer was given for the first sample is ρ_1 and the probability that the same answer was given for the second sample is ρ_2. Combine the samples to obtain a pooled probability that the specific answer occurred, defined as ρ_{12}. Define θ as $(1-\rho_{12})$. A z-value is obtained by the following formula:

$$z = \frac{(\rho_1 - \rho_2)}{[\rho_{12}\ \theta\ (1/\eta_1+1/\eta_2)]^{0.5}} . \qquad (1)$$

If the z-value is statistically significant at the 0.05 level on a table indicating a two-tailed t-distribution, then the two samples are considered to be different.

Two variables were tested to determine the similarity between the mail questionnaire sample and the telephone interview sample: the awareness of the TCE contamination and whether or not the household took specific actions to avoid exposure to TCE. The z-value for awareness of the TCE contamination was:

$$z = \frac{(0.5000 - 0.4324)}{[(0.4364)(0.5636)(\{1/44\}+\{1/703\})]^{0.5}} = 0.8780. \qquad (2)$$

This value is not statistically significant so the telephone interview sample and the mail questionnaire sample were considered to be similar concerning awareness of the contamination.

Of the 304 individuals in the mail questionnaire sample who were aware of the TCE contamination, 133, or 43.75%, took specific actions to avoid exposure to TCE. Comparing this result to 27.27% from the telephone interview sample, the obtained z-value was:

$$z = \frac{(0.2727 - 0.4375)}{[(0.4264)(0.5736)(\{1/22\}+\{1/304\})]^{0.5}} = 1.5105. \qquad (3)$$

This value is also not statistically significant. Thus, based on similar awareness of the TCE contamination and similar proportions taking averting behaviors, the respondents were considered to be representative of the entire sample. Thus, extrapolation of the sample results to the Perkasie population appears justified.

4.6. Total Costs of the Perkasie TCE Contamination

A summary of all estimated costs of TCE contamination incurred by the Perkasie sample is presented in Table 4.2. The Perkasie population consisted of 2760 households. Since the population size was greater than the sample size of 793 households by a factor of 3.48, an extrapolation of the costs to the population was made by multiplying the figures in Table 4.2 by a factor of 3.48. These costs are presented in Table 4.3. The average weekly increase in expenditures for Perkasie during the 88 weeks from the finding of TCE to the first mailing of the questionnaire ranged from $696.74 to $1,492.43. The average weekly increase in averting expenditures per household which undertook some averting actions in response to the contamination ranged from $2.57 to $5.50. Considering all Perkasie households, the average increase per household ranged from $0.25 to $0.54 per week.

Referring back to the conclusions of Chapter 2, these costs represent a lower-bound estimate of the total costs of the TCE contamination incident. Thus, Perkasie residents would have willing to pay a sum of at least $61,313.29 to $131,334.06 to prevent the TCE contamination for the 88 weeks from December 1987 to September 1989.

4.7. Response Rate of the Doylestown Survey

A total of 737 valid questionnaires were received from Doylestown residents. Twenty-two questionnaires were undeliverable and 19 questionnaires were returned but were not valid due to reasons such as the respondent no longer lived in Doylestown or the questionnaire was returned blank. Thus, the effective response rate was 48.6%. This response rate was lower than anticipated and, similar to the Perkasie sample, the possibility of a non-response bias necessitated contacting a random sample of non-respondents. A telephone interview of a random sample of non-respondents indicated that no bias was present. The comparison of the telephone interview results with the results from the mail questionnaires will be detailed in section 4.9.

4.8. Descriptive Results of the Doylestown Survey

The Doylestown questionnaire included a question concerning the source of the water supplied to the respondents household. Of the 732 respondents who answered this question, 676 individuals, or 92.3%, indicated that their water was supplied by the Doylestown Water Works, 51 did not know the source of their water and 5 answered that they had private wells. These 5 respondents were excluded from further analyses.

A total of 210 respondents, or 28.9%, answered that they were taking some averting actions related to water use. Further questions were asked to determine the extent that individual averting behaviors were being undertaken.

Table 4.2 Estimated Costs of the Perkasie TCE Contamination Incurred by Perkasie Sample (December 1987 to September 1989)

Category of Cost	Low Estimate ($)	High Estimate ($)
1. Increased purchases of bottled water	3,199.58	3,199.58
2. New Purchases of bottled water	4,983.32	4,983.32
3. Home water purification systems	1,348.12	1,348.12
4. Hauling water	3,595.62	9,779.16
5. Boiling water	4,492.12	18,429.49
Total	17,618.76	37,739.67

Table 4.3 Estimated Costs of the Perkasie TCE Contamination Incurred by Perkasie Population (December 1987 to September 1989)

Category of Cost	Low Estimate ($)	High Estimate ($)
1. Increased purchases of bottled water	11,134.54	11,134.54
2. New Purchases of bottled water	17,341.95	17,341.95
3. Home water purification systems	4,691.46	4,691.46
4. Hauling water	12,512.76	34,031.48
5. Boiling water	15,632.58	64,134.63
Total	61,313.29	131,334.06

Of the 210 households which were taking averting actions, 167 households, or 79.5%, reported purchases of bottled water. The average amount of bottled water purchased was 3.075 gallons per week. A total of 65 households, or 31.0%, had purchased a home water purification system. The average purchase price of the system was $451.29. Only 5 households indicated they were taking other averting actions, such as boiling water. Since this frequency is low and specific information was not collected concerning other averting behaviors, the cost of other averting behaviors was not calculated.

4.9. Comparison of Doylestown Mail Questionnaire Results with Telephone Interview Results

A copy of the telephone interview forms used to question non-respondents of the mail survey is presented in Appendix G. Of the fifty completed interviews obtained, 49 individuals indicated that their water was supplied by the Doylestown Water Works. A total of 11 individuals, or 22.4%, answered that their household took some averting actions related to water use.

The statistical procedure for comparing the mail questionnaire sample with the telephone interview sample was similar to that utilized for the Perkasie survey, described in section 4.5. The comparison between the Doylestown mail questionnaire and telephone interview samples only included whether or not the respondent's household took any averting actions related to water use. The z-value obtained was:

$$z = \frac{(0.2245 - 0.2889)}{[(0.2852)(0.7148)(\{1/49\}+\{1/727\})]^{0.5}} = 0.9655. \qquad (4)$$

Since this value is not statistically significant, the telephone interview and mail questionnaire samples are similar with respect to averting behavior levels and extrapolation of the results of the survey to the Doylestown population is justified.

4.10. Doylestown Sample Averting Expenditures

Averting expenditures for the Doylestown sample were calculated as a flow of costs. To estimate bottled water expenditures, retail grocers in the Doylestown area were telephoned in December 1989 to obtain an average cost of bottled water. The resulting average cost was $0.87 per gallon. Since 167 respondents were purchasing an average of 3.075 gallons per week, a total of 513.525 gallons per week were being purchased by the sample. Thus, bottled water costs per week were $446.77. The cost of home water purification systems was converted to a weekly cost by assuming that the useful life of such a system is 10 years. Since the average cost of purification systems, including installation, was $451.29 and 65 individuals had purchased systems, the weekly cost of purification systems for the Doylestown sample was $56.41. This figure does not include maintenance or disposal costs. Thus, the weekly averting expenditures for the Doylestown sample were estimated at $503.18.

4.11. Doylestown Population Averting Expenditures

The Doylestown population consisted of 2497 households. Since the sample included 737 of these households, the cost relating to the sample were extrapolated to the population by multiplying by a factor of 3.39. Thus, weekly bottled water costs for the entire community were estimated to be $1,514.55 and weekly purification system costs of $191.23 for a total weekly cost of $1,705.78. The average weekly cost per household was $0.68.

The Doylestown averting expenditure level is assumed to estimate the Perkasie averting expenditure level before the TCE contamination. Adding the assumed averting expenditure level of $0.68 per household per week in Perkasie before the TCE contamination to the calculated average increase of $0.25 to $0.54 per household per week, the average averting expenditure level in Perkasie during the study period ranged from $0.93 to $1.22 per household per week. In other words, average averting expenditure levels in Perkasie increased 37 to 79 percent as a result of TCE contamination, assuming that Doylestown was an appropriate control group. The validity of this assumption will be further explored in sections 4.12, 4.13.3 and 5.5.

4.12. Comparison of Demographic Variables for Perkasie and Doylestown Samples

The validity of using Doylestown as a control group to estimate baseline averting expenditures in Perkasie is dependent upon the similarities of the two communities with respect to risk and demographic factors.

Table 4.4 presents a summary of mean values for certain variables included in both surveys. The hypothesis that the difference of the two means was equal to zero was tested, using t-tests (Bhattacharyya and Johnson, 1977). The Perkasie and Doylestown means were statistically different for half of the variables. For example, Perkasie respondents were more likely to believe that their water supply would be affected by problems in the next few years (excluding the TCE contamination). Also, the Doylestown sample was more educated than the Perkasie sample. Although Perkasie respondents were less likely to be married, they were more likely to have children in the household. The Perkasie sample consisted of a larger proportion of renters. However, the difference may have been due to the different sources used to provided mailing lists. The Doylestown mailing list was comprised of bill-paying water customers. Thus, many renters were assumed to be excluded from the sample. The Perkasie mailing list included all bill-paying electricity customers, which was assumed to include most renters.

Table 4.4 Comparison of Independent Variables of Doylestown and Perkasie Samples (Perkasie mean values only include those respondents who were aware of the TCE contamination)

Variable	Doylestown Mean	Perkasie Mean	t-value
1. FAMILIAR	2.17	2.10	1.94
2. TRUSTPA	2.55	2.57	0.40
3. TRUSTLOC	2.77	2.74	0.62
4. HOME	0.98	0.88	13.57*
5. SCHOOL	5.54	5.05	5.25*
6. INCOME	7.88	7.34	1.81
7. FUTURE	2.72	2.33	6.37*
8. SERIOUS	3.41	3.39	0.52
9. AGE	51.46	43.53	0.47
10. HEALTH	4.28	4.32	0.96
11. MARRIED	0.88	0.81	5.01*
12. INFANT	0.07	0.21	5. 00*
13. CHILD	0.34	0.52	5.27*

* - indicates that the two means are statistically different at the 0.05 level of significance

The validity of the Doylestown sample as a control group would be questioned if any of the variables with different means were significant in the regression results presented in Chapter 5. The possible influence that these differences may have on averting expenditures will be discussed in section 5.5.

Tables indicating the frequencies for variables included in the Perkasie sample, not presented in the text, are included in Appendix H. Frequencies for Doylestown variables, not presented in the text, are given in Appendix I. Note that these frequencies do not include respondents who indicated that they had a private well because these respondents were not considered to be in the study population.

4.13. Risk Analysis

Averting behavior decisions have been hypothesized to be influenced by risk perceptions. This section will present the empirical results of the risk analysis for both communities.

4.13.1. Risk Perceptions of Perkasie Sample

The Perkasie questionnaire asked individuals who were aware of TCE contamination to rate the cancer risk of their water prior to the contamination. The results of this question are given in Table 4.5. Of those who answered the question, the average value was 2.1, slightly higher than “Not a Serious Risk”. Respondents were also asked to rate the cancer risk associated with the levels of TCE in their water. The responses for those who were aware of the TCE contamination are given in Table 4.6. The average response to the question was 2.90, slightly less than “Moderate Risk”.

The average value of P_RATE, the variable which summed all responses to the risk matrix, was 30.22 for the 218 respondents who completed the risk matrix and were aware of the TCE contamination. The average value of P_CANCER (defined in section 3.6) was a perceived increased risk of developing cancer due to TCE contamination of 1 in 242,200. The risk, based on laboratory analyses, associated with the levels of TCE in Perkasie was a 1 in 100,000 risk increase if the contamination lasted a lifetime (70 years). The Pennsylvania Department of Environmental Resources (1986) uses a linear scale for rating different risks. For example, if the contamination lasted 35 years, the risk would be 1 in 200,000. Assuming that the TCE contamination was to last for two years, the actual risk increase would be 1 in 3,500,000 and Perkasie respondents would have overestimated the actual risk levels associated with the TCE contamination. However, if respondents perceived a longer contamination period, the overestimate of the risk would be less significant. Since respondents were not asked the expected length of the contamination incident, an exact determination of risk accuracy cannot be made.

Table 4.5 Qualitative Rating of Cancer Risk of Perkasie Water Prior to TCE Contamination

Risk Category	Frequency	Percentage
1. Insignificant Risk	74	24.3
2. Not a Serious Risk	131	43.1
3. Moderate Risk	68	22.4
4. Serious Risk	12	3.9
5. Very Serious Risk	5	1.6
Missing Values	14	4.6
Total	304	100.0

Table 4.6 Qualitative Rating of Cancer Risk of Perkasie Water Associated With the TCE Contamination

Risk Category	Frequency	Percentage
1. Insignificant Risk	23	7.6
2. Not a Serious Risk	84	27.6
3. Moderate Risk	92	30.3
4. Serious Risk	57	18.8
5. Very Serious Risk	23	7.6
Missing Values	25	8.2
Total	304	100.0

Due to differences among the responses to the risk matrix, a large confidence interval exists around the mean risk perception of 1/242,200 (0.0000041). The 95% confidence interval around this mean was from 1/1 ,250,000 (0.0000008) to 1/129,870 (0.0000077).

4.13.2. Risk Perceptions of Doylestown Sample

The Doylestown sample was asked their qualitative rating of the cancer risk associated with their water. The responses to this question are given in Table 4.7. The average numerical response to this question was 2.2, slightly higher than “Not a Serious Risk”.

The variable D_RATE was defined as the sum of all responses given in the risk matrix as a measure of risk aversion. The average value of D_RATE was calculated as 30.36.

4.13.3. Comparison of Risk Perceptions for Doylestown and Perkasie

Risk attitudes were compared for the two communities by referring to two variables, the qualitative baseline risk perceptions of each community and the risk aversion of the communities as measured by using the proxies of D_RATE and P_RATE. The qualitative risk perception of the Perkasie water before the TCE contamination averaged slightly higher than “Not a Serious Risk”, or a value of 2.1 on the scale used. The qualitative cancer risk perception of the Doylestown water averaged 2.2 on the scale. These values suggested that Perkasie residents perceived the cancer risk of their water before the contamination similar to how Doylestown residents perceived the cancer risk of their water.

The average value of P_RATE was 30.22 with a standard deviation of 6.86. The average value of D_RATE was 30.36 with a standard deviation of 6.27. The hypothesis that the difference of these two means are equal to zero was tested using a t-test (Bhattacharyya and Johnson, 1977). The calculated t-value is 0.30, which is not statistically significant at the 0.05 level. Thus, the similarity of these values indicated that the Doylestown and Perkasie samples responded similarly to the risk matrix. Both communities appeared to be alike in baseline cancer risk perceptions of their water and in responses to the risk matrix. This finding further supports the use of the Doylestown sample as a control group.

4.13.4. Value of a Statistical Life Derived from Perkasie TCE Contamination Incident

Two inferred values of a statistical life were calculated using the low and high estimate of averting expenditures for the Perkasie population due to the TCE contamination. The value of a statistical life was based on the responses to the risk matrix and qualitative risk rating of the TCE contamination. Rather than referring to the 1980 census estimate of Perkasie population (5241 individuals), the population of Perkasie was

Table 4.7 Qualitative Risk Rating of Cancer Risk Associated with Doylestown Water

Risk Category	Frequency	Percentage
1. Insignificant Risk	169	23.1
2. Not a Serious Risk	284	38.8
3. Moderate Risk	203	27.7
4. Serious Risk	20	2.7
5. Very Serious Risk	12	1.6
Missing Values	44	6.0
Total	732	100.0

estimated using the information obtained from the survey to obtain more recent results. The average size per household indicated in the survey was 2.854 individuals. Since the Perkasie population consisted of 2760 household, the estimated population was 7877 individuals. Using the formula presented in section 3.7, the low estimate for the value of statistical life was:

$$\frac{(\$61,313.29)\ (242,200)}{(7877)} = \$1,885,245. \qquad (5)$$

The high value for the value of a statistical life was:

$$\frac{(\$131,334.06)\ (242,200)}{(7877)} = \$4,038,226. \qquad (6)$$

Since the above values are derived from averting expenditure information, they represent lower-bound estimates of the value of a statistical life based on the restrictive assumptions of Chapter 2. Also, since a large confidence interval exists around the mean risk perception (see section 4.13.1), the confidence intervals around the values of statistical life are correspondingly large. The 95% confidence intervals indicate that the lower-bound estimate of the value of a statistical life, based on the data in this study, may range from about \$1,000,000 to \$20,000,000.

The values of a statistical life presented above are within the range of values other researchers have obtained (see Table 2.1). The above values represent the first attempt to infer a value of a statistical life based on averting expenditures. The fact that these results are similar to those obtained by other researchers suggests that the averting expenditure approach to valuing a statistical life is as valid and accurate as other methods for valuing changes in risk.

Chapter 5

REGRESSION RESULTS

5.1. Introduction

The previous chapter demonstrated that averting expenditure methods can be utilized to obtain meaningful empirical results about the cost of water contamination. This chapter will further explore empirical averting expenditure information to gain insight into the factors influencing averting expenditure levels.

An understanding of the factors affecting averting expenditure decisions is useful since some of these factors may be influenced by policy makers. For example, inaccurate risk perceptions may be a partial cause of economically inefficient averting expenditure levels, in which the marginal costs exceed the marginal benefits. Policies could then be designed to educate individuals to perceive risks more accurately, thus bringing about more efficient averting expenditure levels. However, if averting expenditures are significantly influenced by demographic factors, such as income or formal education, then the ability of policy makers to influence averting expenditures could be marginal.

Regression analysis results will be presented for both communities using the variables and procedures described in Chapter 3. The Doylestown analysis will attempt to determine the factors influencing baseline averting expenditures. Perkasie regression results will attempt to determine factors influencing averting expenditure changes during a water contamination incident. The regression results for each community will then be compared.

5.2. Regression Procedures

The initial step in estimating each regression model was to obtain a Pearson correlation coefficient matrix including the dependent variable and all independent variables with various specifications. From the matrix, independent variables with a significant correlation to the dependent variable (0.05 level of significance) were included in initial regression equations. Thus, a regression model was produced for each specification of the dependent variable (unadjusted and natural logarithm). An additional regression was run for each specification which included only those variables whose parameter estimates were significant at the 0.10 level in the initial regression. The results were used to test the hypothesis that the insignificant variables, as a whole, did not significantly add explanatory power to the models.

Pindyck and Rubinfeld (1981) define the initial regression model as the unrestricted model (UR):

$$Y = \beta_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon \qquad (1)$$

where $k-1$ independent variables are being considered to explain the dependent variable (Y) and ε is a random error term. The hypothesis that some subset of the parameter estimates (β's) are equal to zero can be tested by means of an F-test. Suppose that the parameter estimates for q variables are hypothesized to be jointly equal to zero, the restricted model (R) is defined as:

$$Y = \beta_1 + \beta_2 X_2 + \ldots + \beta_{k-q} X_{k-q} + \varepsilon. \qquad (2)$$

The null hypothesis is that $\beta_{k-q+1}=\ldots\beta_k=0$. The appropriate F-statistic to test this hypothesis, using R^2 values, is:

$$\frac{(R^2_{UR} - R^2_R) / q}{(1 - R^2_{UR}) / (N-k)} \qquad (3)$$

where N is the number of observations in the data set. This value will have an F distribution with q degrees of freedom in the numerator and (N-k) in the denominator. If this value exceeds the critical value of the F distribution at the 0.05 level of significance, the null hypothesis that the last q parameter estimates are jointly equal to zero is rejected. In other words, the q variables significantly add explanatory power to the model and should not be excluded from the model, even though the estimates of their individual coefficients are not significantly different from zero.

The presence of multicollinearity will be examined along with any possible remedies. Pindyck and Rubinfeld (1981, p.89) indicate that “a rule of thumb states that multicollinearity is likely to be a problem if the simple correlation between two variables is larger than the correlation of either or both variables with the dependent variable”. Kennedy (1985) notes that correlation coefficients of 0.8 or 0.9 in absolute value indicate a high correlation between independent variables. Kmenta (1971, p.390) states that another criterion is that “multicollinearity is regarded as harmful if at, say the 5% level of significance, the value of the F statistic is significantly different from zero but none of the t statistics for the regression coefficients (other than the regression constant) are”. Each of these criteria was considered to determine if multicollinearity was a problem in the regression models.

5.3. Doylestown Regression Results

The dependent variable considered in the first model developed from the Doylestown data was the estimated yearly household averting expenditures. The income variable was found to be most significantly correlated with averting expenditures when specified as a dummy variable equal to 1 if household income was $50,000 per year or greater and assigned a value of 0 if household income was below $50,000 per year. The Pearson correlation coefficients of all independent variables related to the dependent variable, including significant relationships, is given is Table 5.1.

Evidence of multicollinearity appeared in some of the relationships of the independent variables. The correlation coefficient of the trust variables with each other was 0.707 and both were highly correlated with the risk variables. The trust variables were considered to be similar enough to be combined to form a trust index (TRUST) which was defined as (TRUSTLOC+TRUSTPA) . Another indication of multicollinearity existed between AGE and CHILD, with a Pearson correlation coefficient of 0.555. However, no steps were taken as a result of this relationship since the variables represent different demographic factors. All other correlations were below 0.40 so multicollinearity was not considered to be a serious problem in the model. The model specification including all independent variables that were significantly correlated to the dependent variable, along with parameter estimates, is presented in Table 5.2.

A restricted model was developed which excluded the nine variables whose parameter estimates were not significant at the 0 10 level. The R2 value for the restricted model was 0.1243. Using the R2 value for the unrestricted model (0.1633 from Table 5.2), the appropriate F-statistic to test the hypothesis that the parameter estimates for the nine independent variables are jointly equal to zero is:

$$\frac{(0.1633-0.1243)/9}{(1-0.1633)/(463-15)} = 2.32. \qquad (4)$$

Since this value is greater than the critical F value (1.88) with ∞ degrees of freedom in the denominator and nine degrees of freedom in the numerator, the null hypothesis was rejected. Thus, the insignificant variables add to the explanatory power of the model and are included in the results.

The signs of all significant relationships were in the hypothesized directions. Doylestown residents were likely to have greater averting expenditures if they were aware of problems with the water, rated the cancer risk of the water high, had a child under 3 years of age, had an income of $50,000 per year or higher and anticipated future problems with their water.

The other specification of the dependent variable for the Doylestown data set was the natural logarithm of the yearly averting expenditures. The dependent variable in this case was normalized to a value of 0 for any respondent who had no averting expenditures by setting averting expenditures equal to 1 before the logarithmic transformation. The income variable was again specified as a dummy variable indicating household income above or below $50,000 per year.

The Pearson correlation coefficients of all independent variables related to the transformed dependent variable are given in Table 5.3. The correlation matrix among independent variables did not change as a result of the specification of the dependent variable so the multicollinearity

Table 5.1 Pearson Correlation Coefficients of Independent Variables to Doylestown Averting Expenditures

Independent Variable	Correlation Coefficient	Independent Variable	Correlation Coefficient
1. FAMILIAR	0.106*	11. INFANT	0.124*
2. SERIOUS	0.102*	12. CHILD	0.073*
3. TRUSTPA	-0.118*	13. SMOKE	-0.011
4. TRUSTLOC	-0.134*	14. EXERCISE	0. 082*
5. FUTURE	-0.216*	15. AGE	-0.114*
6. SCHOOL	0.105*	16. GENDER	-0.048
7. HEALTH	0.023	17. MARRIED	0.018
8. JOBRISK	0.072	18. D_RISK	0.211*
9. INCOME	0.122*	19. D_RATE	0.115*
10. HOME	0.085*	20. D_PROB	0.262*

* indicates a coefficient significant at the 0.05 level

Table 5.2 Regression Results from Doylestown Sample (Dependent Variable - Estimated Yearly Averting Expenditures)

Number of Observations: 463
F-Value: 6.455 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.1633 Adjusted R-Squared Value: 0.1380

Variable	Parameter Estimate	T-Value
Intercept	-27.989	-0.540
D PROB	42.635	5.240***
D–RISK	10.513	2.531**
INFANT	27.238	2.517**
INCOME	13.995	2.155**
FUTURE	-8.411	-1.874*
CHILD	-3.580	-0.507
FAMILIAR	5.076	1.196
SERIOUS	-2.090	-0.444
TRUST	-1.450	-0.599
SCHOOL	2.197	0.677
AGE	-0.478	-1.750
HOME	38.678	1.278
D RATE	0.186	0.344
EXERCISE	3.247	1.396

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level
* - indicates statistical significance at the 0.10 level

Table 5.3 Pearson Correlation Coefficients of Independent Variables to Natural Logarithm of Doylestown Averting Expenditures

Independent Variable	Correlation Coefficient	Independent Variable	Correlation Coefficient
1. FAMILIAR	0.099*	11. INFANT	0.110*
2. SERIOUS	0.125*	12. CHILD	0.073
3. TRUSTPA	-0.179*	13. SMOKE	-0.002
4. TRUSTLOC	-0.168*	14. EXERCISE	0.100*
5. FUTURE	-0.231*	15. AGE	-0.136*
6. SCHOOL	0.164*	16. GENDER	0.029
7. HEALTH	0.051	17. MARRIED	0.000
8. JOBRISK	0.053	18. D_RISK	0.241*
9. INCOME	0.118*	19. D_RATE	0.155*
10. HOME	0. 074*	20. D_PROB	0.271*

* indicates a coefficient significant at the 0.05 level

adjustments were the same as the previous model. The trust variables were again added to form the variable, TRUST.

The regression model using those independent variables which were correlated with the dependent variable at the 0.05 level of significance is presented in Table 5.4. All signs are in the hypothesized direction (except for AGE and SCHOOL for which no hypothesis was made). The positive parameter estimate of SCHOOL indicates that individuals who were more educated tended to have higher averting expenditures. Also, younger individuals tended to have greater averting expenditures than older individuals.

Another regression was run which excluded the six variables whose parameter estimates were not statistically significant at the 0.10 level. The R^2 value for this restricted regression was 0.1606. The appropriate F-statistic to test for the null hypothesis that the insignificant parameter estimates of the six excluded variables are jointly equal to zero is:

$$\frac{(0.1972-0.1606)/6}{(1-0.1972)/(463-14)} = 3.41. \qquad (5)$$

This value is greater than the appropriate F distribution critical value (1.88). Thus, the six insignificant variables are included in the regression results since they significantly add to the model's explanatory power.

5.4. Perkasie Regression Results

The first regression model utilizing the Perkasie data set specified the dependent variable as the change in household averting expenditures as a result of the TCE contamination. As evident from the Pearson correlation coefficients presented in Table 5.5, only a few independent variables were significantly correlated with the dependent variable at the 0.05 level. The variable INCOME was not correlated with the dependent variable regardless of how INCOME was specified so no coefficient is given in Table 5.5. None of the correlation coefficients between the significant variables were above 0.40 in absolute value so multicollinearity was not considered to be a serious problem in the model.

The resulting parameter estimates are presented in Table 5.6. The signs of the parameter estimates are in the hypothesized directions for P TCE, CHILD and INFANT. No hypothesis was made concerning the expected influence of P_OTHER. The positive parameter estimate for P_OTHER indicates that awareness of water problems other than the TCE contamination contributed to a higher increase in averting expenditures. This can be interpreted as an indication that the other problems were not considered a health risk sufficient to undertake averting actions such that no additional actions were necessary due to the TCE contamination.

Since only one variable (TRUSTLOC) was not statistically significant in Table 5.6, a joint F-test was not necessary. Since the parameter

Table 5.4 Regression Results from Doylestown Sample (Dependent Variable - Natural Logarithm of Estimated Yearly Averting Expenditures)

Number of Observations: 463
F-Value: 8.125 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.1972 Adjusted R-Squared Value: 0.1730

Variable	Parameter Estimate	T-Value
Intercept	-1.862	-1.290
D PROB	1.067	4.681***
D-RISK	0.390	3.373***
HOME	2.123	2.521**
SCHOOL	0.170	1. 882**
AGE	-0.016	-2.071**
INFANT	0.551	1.829*
TRUST	-0.113	-1.676*
INCOME	0.201	1.114
CHILD	-0.006	-0.032
FAMILIAR	0.090	0.760
SERIOUS	-0.016	-0.125
D RATE	0.009	0.615
EXERCISE	0.098	1.512

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level
* - indicates statistical significance at the 0.10 level

Table 5.5 Pearson Correlation Coefficients of Independent Variables to Perkasie Averting Expenditure Increase Associated with TCE Contamination

Independent Variable	Correlation Coefficient	Independent Variable	Correlation Coefficient
1. FAMILIAR	0.072	13. SMOKE	0.026
2. SERIOUS	0.067	14. EXERCISE	0.085
3. TRUSTPA	-0.089	15. AGE	-0.100
4. TRUSTLOC	-0.203*	16. GENDER	0.104
5. FUTURE	0.027	17. MARRIED	-0.104
6. SCHOOL	0.035	18. P_BEFORE	0.077
7. HEALTH	-0.030	19. P_TCE	0.226*
8. JOBRISK	0.011	20. P_RATE	0.111
9. INCOME	---	21. P_CANCER	-0.056
10. HOME	-0.045	22. P_INFO	0.051
11. INFANT	0.188*	23. P_OTHER	0.168*
12. CHILD	0.169*		

* - indicates statistical significance at the 0.05 level

Table 5.6 Perkasie Regression Results (Dependent Variable - Estimated Household Averting Expenditures Resulting from TCE Contamination)

Number of Observations: 261
F-Value: 7.608 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.1272 Adjusted R-Squared Value: 0.1105

Variable	Parameter Estimate	T-Value
Intercept	-5.368	-0.123
P_TCE	22.196	2.915***
INFANT	47.432	2.514**
CHILD	33.901	2.171**
P_OTHER	41.590	2.093**
TRUSTLOC	-10.387	-1.020

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level

estimate of TRUSTLOC was not significant at the 0.05 level, the hypothesis that the estimate is equal to zero can not be rejected and the inclusion of TRUSTLOC does not significantly add to the explanatory power of the model. Regression results excluding TRUSTLOC are presented in Table 5.7.

The other specification of the dependent variable for the Perkasie data set was the natural logarithm of the change in averting expenditures associated with the TCE contamination. Similar to the Doylestown analysis, the dependent variable was normalized to a value of 0. Table 5.8 presents the Pearson correlation coefficients of independent variables related to the dependent variable. The income variable was not significantly correlated with the dependent variable under any specification. Since the correlations between the independent variables did not change as a result of the specification of the dependent variable, multicollinearity was not considered to be a serious problem in the model.

The regression model that resulted from the correlation matrix is presented in Table 5.9. The sign of INFANT is in the predicted directions. The sign of P_INFO suggested that the information respondents received or obtained concerning the health risks of TCE and the actions that could be taken to avoid exposure influenced them to take specific averting actions. Thus, the obtained or received information probably indicated that the health risks of TCE were large enough to take specific actions. The sign of P_BEFORE indicates that averting expenditure increases were higher among those who rated the cancer risk of the water higher before the TCE contamination. Also, male respondents indicated a greater increase in averting expenditures than females.

A restricted regression was run which excluded the nine variables whose parameter estimates were not statistically significant at the 0.10 level in the unrestricted regression. The R^2 value of the restricted model was 0.1255. The appropriate F-statistic to test the null hypothesis that the parameter estimates for all nine insignificant variables are jointly equal to zero is:

$$\frac{(0.1629-0.12551/9}{(1-0.1629)/(257-14)} = 1.208. \qquad (7)$$

This value is less than the critical F-value (1.88) so the null hypothesis can not be rejected and the conclusion follows that the nine variables do not significantly add to model's explanatory power. The regression results which included only the variables INFANT, GENDER, P_BEFORE and P_INFO are presented in Table 5.10.

5.5. Regression Alternatives

Ordinary least-squares is not the only statistical means to analyze averting expenditures. Inspection of the correlation matrices and further analysis indicated that averting expenditure decisions may be hypothesized as a two-stage process. In the first stage, individuals determine their risk perception of an environmental factor. In the second stage, they

Table 5.7 Perkasie Regression Results (Dependent Variable - Estimated Household Averting Expenditures Resulting from TCE Contamination, Only Significant Variables)

Number of Observations: 266
F-Value: 9.562 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.1257 Adjusted R-Squared Value: 0.1126

Variable	Parameter Estimate	T-Value
Intercept	-43.747	-1.927XX
P_TCE	24.779	3.480***
CHILD	49.711	2.678***
INFANT	36.385	2. 378**
P_OTHER	45.230	2.336**

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level

Table 5.8 Pearson Correlation Coefficients of Independent Variables to Natural Logarithm of Perkasie Averting Expenditure Increase Associated with TCE Contamination

Independent Variable	Correlation Coefficient	Independent Variable	Correlation Coefficient
1. FAMILIAR	0. 083*	13. SMOKE	-0.072*
2. SERIOUS	0. 089*	14. EXERCISE	0.016
3. TRUSTPA	-0.022	15. AGE	-0. 086*
4. TRUSTLOC	-0.040	16. GENDER	0.079*
5. FUTURE	0.034	17. MARRIED	-0.104*
6. SCHOOL	0.102*	18. P_BEFORE	0.173*
7. HEALTH	0.032	19. P_TCE	0.067
8. JOBRISK	-0.033	20. P_RATE	0.034
9. INCOME	---	21. P_CANCER	0.002
10. HOME	-0.141*	22. P_INFO	0.143*
11. INFANT	0.236*	23. P_OTHER	0.142*
12. CHILD	0.142*		

* - indicates statistical significance at the 0.05 level

Table 5.9 Perkasie Regression Results (Dependent Variable - Natural Logarithm of Estimated Household Averting Expenditures Resulting from TCE Contamination)

Number of Observations: 257
F-Value: 3.846 (Entire Model is significant at the 0.01 level)
R-Squared Value: 0.1629 Adjusted R-Squared Value: 0.1205

Variable	Parameter Estimate	T-Value
Intercept	-1.373	-0.956
INFANT	1.129	3.188***
P INFO	0.323	2.812***
P-BEFORE	0.473	2.791***
GENDER	0.537	1.798*
CHILD	0.054	0.173
P_OTHER	0.442	1.220
SERIOUS	0.281	1.431
FAMILIAR	-0.067	-0.293
SCHOOL	0.070	0.536
HOME	-0.529	-1.105
SMOKE	-0.178	-0.463
AGE	-0.006	-0.530
MARRIED	-0.197	-0.463

*** - indicates statistical significance at the 0.01 level
* - indicates statistical significance at the 0.10 level

Table 5.10 Perkasie Regression Results (Dependent Variable - Natural Logarithm of Estimated Household Averting Expenditures Resulting from TCE Contamination, Only Significant Variables)

Number of Observations: 280
F-Value: 10.048 (Entire Model is significant at the 0.01 level)
R-Squared Value: 0.1255 Adjusted R-Squared Value: 0.1130

Variable	Parameter Estimate	T-Value
Intercept	-1.140	-1.773*
INFANT	1.313	4.063***
P_ INFO	0.297	2.541***
P_BEFORE	0.454	3.040***
GENDER	0.536	1. 984**

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level

chose to undertake a certain level (if any) of averting behavior based on this risk perception. If averting expenditure decisions are in fact a two-stage process, ordinary least-squares may produce results which are biased and inconsistent (Pindyck and Rubinfeld, 1981). The survey instrument of this study did not attempt to elicit information concerning the determinants of risk perceptions. Consequently, the capability of this study to define a two-stage process was limited. However, statistical analysis of this process was attempted using two-stage least squares and is summarized in Appendix J.

5.6. Comparison of Doylestown and Perkasie Regression Results

The qualitative risk perception of the water proved to have a significant positive relationship with the averting expenditure dependent variable in all but one of the models. Thus, qualitative risk perception does appear to influence averting decisions.

The presence of children under three years of age in the household influenced averting expenditures in all models. This finding can be interpreted by suggesting that parents may take averting actions because of concerns about the health of their young children. Also, the awareness of water problems, in the Doylestown sample, or additional problems, in the Perkasie sample, positively influenced averting expenditures in all but one of the models presented. Income affected baseline averting expenditures but not averting expenditure changes in response to a water contamination incident.

The regression results present some indication of the validity of Doylestown as a control group to estimate Perkasie baseline averting expenditures. Of the independent variables whose means were statistically different at the 0.05 level (see Table 4.4), only the variable INFANT appeared as significant in both Doylestown regression models (see Tables 5.2 and 5.4). Since Perkasie respondents were more likely to have children under three years of age in the household and INFANT positively influenced baseline averting expenditures, an inference can be made concerning baseline averting expenditures in Perkasie. If INFANT was assumed to positively influence averting expenditures in Perkasie before the TCE contamination, then, based only on the difference in INFANT, Perkasie would have a greater baseline averting expenditure level than Doylestown. However, the magnitude of this effect would be less than five percent. In other words, the data suggests that Perkasie baseline averting expenditures were no more than five percent greater than those in Doylestown due to the difference in the INFANT variable.

The mean value of FUTURE was statistically different in the two samples and appeared as significant in the Doylestown regression result with the dependent variable as estimated yearly averting expenditures (see Table 5.2). However, expectations of future water quality problems among the Perkasie sample may have been influenced by the TCE contamination. The difference in the mean value of FUTURE may have been due to the TCE contamination and not different attitudes of the samples. Also, the mean value of HOME was statistically different in the samples and appeared as significant in the Doylestown regression results with the dependent variable as the natural logarithm of estimated yearly expenditures (see Table 5.4). As stated previously, the difference in the mean value of HOME may have been due to the different sources which provided mailing lists instead of differences in the proportion of renters in the two communities. Thus, the significance of FUTURE and HOME in the Doylestown regression results do not seem to significantly threaten the validity of Doylestown as a control group.

The statistical significance of the risk perception variables indicated that risk perception changes brought about by policies could affect averting expenditures. The policy implications of the regression results are presented in the next chapter.

Chapter 6

CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Introduction

This research has theoretically and empirically explored the applicability of the averting behavior method towards valuing household water quality. This chapter will summarize major findings, identify limitations of the study and discuss policy implications. The results are discussed in terms of progress towards reaching the six objectives outlined in Chapter 1. Finally, suggestions for future research in the economic valuation of environmental improvements will be made.

6.2. Summary of Conclusions

The first objective was to analyze the existing controversy about the theoretically correct interpretation of averting expenditures. The models developed in this study have indicated that averting expenditures can be theoretically related to WTP for marginal and non-marginal changes in environmental quality. Under specific assumptions, the change in averting expenditures associated with a change in environmental quality provides a lower-bound estimate of the true cost, or benefit, of the environmental change. The diagrammatic analysis representing non-marginal changes, presented in Chapter 2, concluded that some determination can be made regarding the accuracy of the change in defensive expenditures in estimating theoretical measures of WTP. A relatively large change in defensive expenditures associated with a change in environmental quality, measured by such methods as budget share or per household expenditures, is a more accurate estimate of compensating variation and equivalent variation expenditures than a relatively small change in defensive expenditures. Since most water contamination incidents involving public notification may be considered non-marginal changes in water quality, the AB method appears to be a theoretically appropriate technique to measure the costs of water contamination incidents.

The second objective was to review relevant literature on environmental valuation methods to develop the foundations of the AB method and compare it with other methods. Each of the most commonly used methods; cost-of-illness, contingent valuation and averting behavior, was found to have strengths and weaknesses such that a “correct” method for any situation is not available. The strengths of the AB method include direct derivation of estimates based on actual behavior as opposed to hypothetical behavior, the ability to relate AB measures to WTP, and a strong foundation in the household production function of consumer theory. The weaknesses of the AB method include interpretation difficulties if certain assumptions are not satisfied and normally requiring the collection of primary data.

Data on the averting expenditures of households in two communities, Doylestown and Perkasie, Pennsylvania, was collected to accomplish the third objective of empirically estimating the costs of a water contamination incident. Mail questionnaires were utilized to elicit information from households. Doylestown was utilized as a control group to estimate baseline (prior to water contamination) averting expenditures for Perkasie. Averting expenditures caused by a TCE contamination in Perkasie were estimated from information collected in the questionnaire. The magnitude of averting expenditures caused by the contamination incident was found to be quite high relative to baseline averting expenditures. Specifically, averting expenditures in Perkasie increased by at least 37% during the TCE contamination.

The fourth objective was to develop an alternate method of risk elicitation. Based on experience from a pilot project conducted prior to this study, a “risk matrix” approach was developed and implemented in the mail questionnaires. These surveys represent the first attempt to collect empirical data using this approach. About three-fourths of survey respondents completed the risk matrix. Considering the difficulty of eliciting risk perceptions, this proportion of responses does not appear to be excessively low. Also, since the risk matrix was successfully utilized to calculate values of a statistical life, the refinement and further use of the risk matrix approach could yield acceptable results in future risk studies.

The fifth objective focused on explaining relationships between averting expenditure levels, risk perception and other factors. The regression results in Chapter 5 demonstrated that qualitative risk perception is an important determinant of averting decisions. Other factors that influenced averting expenditures included the presence of young children in a household, awareness of water quality problems and expectations of future water quality.

The last objective was to calculate the value of a statistical life from risk perceptions and averting expenditures associated with a water contamination incident. This was accomplished in Chapter 4 using information related to the Perkasie TCE contamination. Although the values obtained had rather large confidence intervals, they were within the ranges other researchers have calculated. The values of a statistical life presented in this research, approximately $2 to $4 million, represent the first values based on household averting expenditures.

6.3. Research Limitations

The theoretical and empirical results presented in this study may be limited by several factors. First, the validity of using averting expenditure changes to provide a lower-bound estimate of the compensating and equivalent valuations of an environmental change is based on assumptions which may sometimes be violated. All Perkasie averting expenditure estimates presented in Chapter 4 were considered to be a direct result of TCE contamination. However, other reasons may have influenced some purchases. For example, individuals may have regarded bottled water as tasting better than tap water. If this were true, only a part of the cost of bottled water should have been considered a direct result of the contamination.

Another potential limitation is that averting expenditure measures provide only a lower-bound estimate of the true cost of environmental changes. Research has not determined with precision the accuracy of averting expenditures in estimating true costs. While this research has indicated that some determination can be made concerning the accuracy of the AB approach in estimating true costs, no standard exists for relative determination of this accuracy. This limitation leads to the suggestion that future research may be able to determine the accuracy of the AB approach in estimating true costs of environmental contamination.

The assumption that Doylestown was an appropriate control group used to estimate baseline averting expenditures in Perkasie before the TCE contamination appeared correct except for the difference in the presence of young children among the two communities. However, due to the relatively low explanatory power of the regression models presented in Chapter 5, the presence of young children in the household did not appear to have a large influence on baseline averting expenditures. Thus, the loss of validity that this difference may have on the use of Doylestown as a control group did not appear to be significant.

While the risk matrix approach was successful for determining risk perceptions and for calculating the value of a statistical life associated with the Perkasie TCE contamination, this study represents the first attempt to empirically employ this approach. The responses to the risk matrix may have been influenced by biases, such as the strategic bias of overstating risk perceptions to influence the results of the questionnaire.

Another limitation is the low explanatory power of the regression models presented in Chapter 5. While the models did indicate that risk perception influences averting expenditures, the R-squared values demonstrated that much of the variance in averting expenditures was not explained by the models.

6.4. Policy Implications

The research findings have at least three major implications for public policy. First, the lower bound measures of the economic value of water quality changes obtained via averting expenditures analysis are of sufficient empirical importance that they should be considered in federal, state and local decision-making. This study revealed that the costs of averting expenditures in specific water contamination incidents can increase significantly. Averting expenditures increased an average of 58 percent per household (about 39.5 cents per week) in a community after public notification of TCE contamination. These estimates also have considerable theoretical support. Under certain assumptions, averting expenditures provide the lower-bound estimate of the true costs of marginal and non-marginal environmental changes. The method's assumptions appear to be generally valid to the situation of drinking water contamination. Thus, averting expenditures should be included in cost-benefit analyses of public policies where averting actions are an option for affected individuals. Examples of such policy decisions include: setting of federal Maximum Contaminant Levels (MCLs) for drinking water, establishing state water quality policies and water quality standards, and local decision-making to protect or remediate the quality of water supplies. Failure to consider averting expenditures in water resources decision-making is likely to result in inefficient policies. For example, the costs of water contamination incidents would be understated if averting expenditures were excluded. Understating the costs associated with water contamination would lead to policies which set allowable levels of water contamination too high.

Second, the study shows that averting actions vary significantly with differences in people's perception of the severity of the risk. Furthermore, there is evidence that differences in risk perception, though difficult to explain with the variables considered, can be due to some individuals misunderstanding the facts about the risk posed by a contaminant in their water. Another factor influencing risk perception may be the difference in the way people evaluate different numerical risks; what is rated as a minor risk by some is considered very serious by others. Different policy actions are implied by each of these two sources of differences in risk perceptions. Errors in understanding the nature of the risk from particular contaminants imply a program of information designed so the facts are readily understood by people who are not scientifically trained. Likewise, the audience for these programs may include a significant number of individuals who are not likely to take a great deal of time to study the issue. The challenge is to devise public educational programs that are factually correct, easy to understand and credible.

The differences in the way people value a given risk imply a different kind of policy choice. While there may be some appropriate ways to help individuals decide if a risk is "serious" or not, the diversity of human preferences, including the preference for avoiding risks, suggests large differences will still persist in the way individuals regard a given, well-understood risk. In the case of water quality protection, this implies that public programs to control the level of risk from contamination may need to have alternatives available for those with different risk perceptions. For example, a program of periodic testing and treatment to keep carcinogen concentrations below levels that project an increase in cancer risk of one in a million from a lifetime exposure may be deemed appropriate by a large portion of the population. For those who believe this is inadequate protection, the water supply agency could help them further reduce the risks using a voluntary group plan for low cost purchase and regular maintenance of home water treatment systems. This feature would provide added protection for those who prefer it, but at a cost which is lower than they would otherwise have to pay. Policies that promote choice among alternative levels of protection from risk may be essential to accommodate persistent differences in risk perceptions and evaluations.

The third policy implication concerns individuals' awareness of specific water contamination incidents. Only 43% of Perkasie respondents realized that TCE was present in their water. This figure is less than half the level of awareness found by Abdalla (1989), where 96% of the respondents in a community were aware of a water contamination incident. Notification of water customers was required for both water contamination incidents. This suggests a lack of consistency and effectiveness in present notification procedures. Two factors appeared to contribute to this difference in awareness; the method of public notification and media coverage. Perkasie residents were notified of TCE contamination via a newsletter which was included with their regular water bill. Residents of the community in the pilot study were notified of contamination via a letter specifically informing them of the contamination. Individuals may be less likely to read a newsletter included with their water bill than a separate letter. A more uniform procedure for notification could make individuals more aware of water contamination problems. Also, evidence suggested that the contamination episode of the pilot study received considerably more media coverage than the Perkasie incident. Awareness of water contamination incidents may increase if the water supply agency was required to notify its customers through local newspapers as well as via mailings.

The regression results in Chapter 5 indicate that households may not be equally concerned with health risks posed by contaminants in drinking water. Notification procedures may be intensified towards those groups which appear to be more concerned with water quality. For example, households with young children tend to spend more on averting activities related to water use. Notification programs targeted at parents of young children could be developed, such as through child care centers or pediatricians' offices.

6.5. Suggestions for Future Research

This study has demonstrated that the averting behavior method is useful in valuing changes in environmental quality. Theoretical support indicates the ex ante costs of future water contamination incidents can be studied using the AB. Also, predictions can be made concerning the effects that certain policies may have on averting expenditure levels.

There are some avenues of research opened by this study that warrant further work. One such area is the attempt to relate quantitative statements of risk to individuals' qualitative judgments of the seriousness of the risk. The risk matrix approach developed in this study elicited consistent responses from most of the respondents and the results were used to calculate values of a statistical life. The wide range in the numerical risks that people associated with each qualitative judgement of the seriousness of the risk contributed to a large confidence interval around these values of a statistical life which makes the results less helpful than was expected. One possible explanation is that the samples (and the total populations) included several groups of people with different attitudes towards cancer risks. There may be some that consider any risk, no matter how small, to be “serious” and worth a large expenditure to avoid. There may be others who dismiss all of the risks as “not serious” or “insignificant” and not worth bothering about. Between these extremes, several other groups may be delineated based on different aspects of their attitudes towards risk. There is evidence in the present risk matrix study that there are some people who hold the extreme views listed above. Further analysis and a more detailed inquiry into this aspect of risk preference would be necessary to determine if other groups could be identified.

Another avenue of research is to relate the averting behavior approach to other methods of valuation, such as hedonic pricing or contingent valuation. Since averting expenditures are a lower-bound to the value people place on avoiding risk, there may be policy choices where an estimate of the additional value is needed. In certain situations, such as the contamination of a groundwater source, the averting behavior approach may be combined with another method, such as contingent valuation, to obtain an estimate closer to the true willingness to pay to avoid the risk. For example, averting expenditure techniques could be used to determine the level of actual expenditure made by each respondent. Then, a contingent valuation question could be asked to determine the willingness to pay for avoiding the risk.

This study has indicated that the accuracy of averting expenditure changes in estimating willingness-to-pay depends on the relative magnitude of averting expenditure changes. A “large” change in averting expenditures is a more accurate estimate of WTP than a “small” change. However, no information is available on what constitutes a “large” or “small” change in averting expenditures. Future studies could measure relative budget shares of averting expenditure changes to determining the accuracy of the AB method.

The low explanatory power of the regression results indicate that more information about the determinants of averting expenditures needs to be collected. Also, the role of risk perception is not fully understood. Survey instruments could be designed to better determine the factors affecting risk perception. This information could be used to develop a more useful two-stage model of averting expenditures than that presented in Appendix J.

Hopefully, the information presented in this study will provide the impetus for future studies in valuing environmental quality. A better theoretical and empirical understanding of the applicable methods to economically value changes in environmental quality can lead to policies which are more efficient and effective in improving environmental quality. The benefits of more intelligent and responsible environmental policies are not only likely to be immediately apparent, but continue far into the future.

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Appendix A

Copy of Quantitative Risk Elicitation Method Used for Lemont Pilot Study

Household Activity and Water Quality Survey

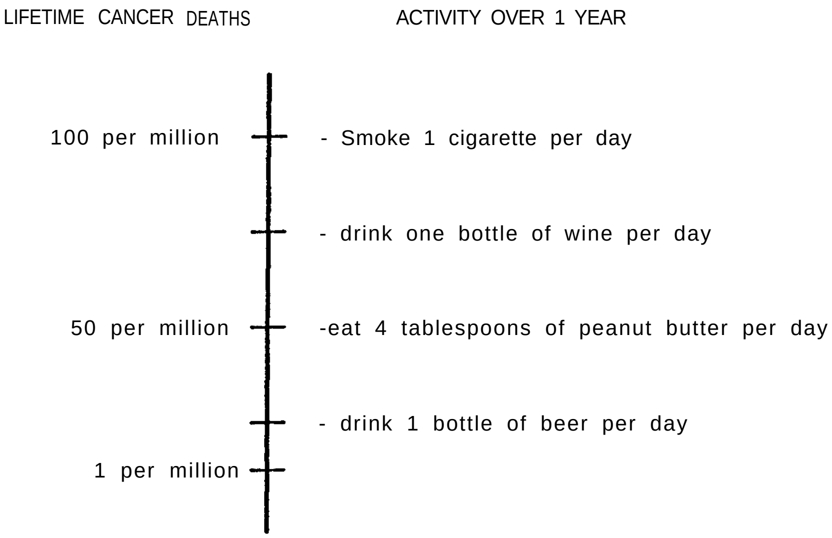
Question - Health Risks of P.C.E. in Water

In the questionnaire you returned to us, you rated the health risk from Perchloroethylene (PCE) in the water supplied to your home by the Lemont Water Company from July 1987 to December 1987 as *** The possible answers were: 1. Insignificant risk, 2. Very low risk. 3. Low risk, 4. Moderate risk, 5. High risk. 6. Very high risk.

Would you help us further by answering the question below?

The chart below shows the additional risk of getting cancer during a person's lifetime if they undertake certain activities for one year. Numbers on the left side represent the number of additional cancer deaths over a lifetime. Activities on the right side have been found to be associated with cancer at the levels indicated. For example, eating 4 tablespoons of peanut butter a day for a year will cause 50 extra cancer deaths per million people who undertake this activity.

In terms of the information, how would you rate the health risks associated with the levels of PCE in your water from July 1987 to December 1987? Please indicate your choice, marking the chart below with a horizontal line.



Thank you!

Please fold and return in the self-addressed, stamped envelope enclosed.

***** -** indicated qualitative risk perception from initial survey

Appendix B

Copy of Letter Notifying Perkasie
Residents About the Presence of TCE
in the Water

WATER AND
WASTE WATER
SERVICE

Perkasie Borough Authority
306 N Fifth Street P.O. Box 159
Perkasie, PA 18944
(215) 257-3654

January, 1989

TO: Perkasie Borough Authority Customers

In November, 1988 the Authority acquired the property formerly owned by the J. Melvin Freed Glass Company at 306 North 5th Street, Perkasie. Beginning January 30, 1985 all Authority business will be conducted from this location.

For the past three years the Authority has had an urgent need for additional space, both office and garage. Various options were explored to expand at our 7th Street location or to look elsewhere for suitable quarters. When the Freed property became available, it was quickly recognized that with only minor renovations, it would be ideally suited to our use. It provides us with the space so sorely needed immediately, as well as the flexibility to expand in the future as our needs increase.

Beginning January 30, 1989, all office personnel will be moved to the new location. The balance of the Authority operations will follow shortly. Effective immediately all mail should be addressed to:

P.O. Box 159, Perkasie, PA 18944

The telephone number is unchanged: **257-3654**

All customers were previously advised of the TCE contamination encountered in one of the Authority wells in South Perkasie. This well continues to be monitored on a weekly basis with the concentrations still remaining above the maximum contaminant level established by the United States Environmental Protection Agency. However, the concentrations in our well are only considered to be harmful if consumed in large quantities over an extended period of time. Pennsylvania Department of Environmental Resources publications state that 2 liters of water (slightly more than 2 quarts) consumed daily for 70 years would result in 1 out of 100,000 people developing some form of cancer.

In order for us to meet our water demand, and still comply with withdrawal limitations imposed by regulatory agencies, it is necessary for us to continue use of this well until our new well on East Walnut Street is in operation. We expect that will be within a few months. At that time the use of the TCE well will be reduced or discontinued to bring our water quality into conformance with existing regulations. The source of contamination, at least in part, has been identified by the PA Department of Environmental Resources. Efforts are being made to remove the TCE from the groundwater but it is a condition that cannot be quickly or easily corrected.

If anyone is apprehensive about drinking the water, 90% of the TCE can be removed by bringing the water to a rolling boil for two minutes in a well ventilated room. While the risk factor in consuming the water is minimal the Authority will be reducing withdrawals from the well as soon as possible.

At this time of the year, when water seems to be plentiful, people are rarely concerned with conservation measures. We all have a tendency not to worry about water until the well runs dry. This is a fallacy that should be corrected at all costs. Water conservation measures are just as important during the winter months as they are in the summer, perhaps more so. What is saved in the winter will be available during the summer months when supplies normally dwindle. Following are a few hints on conserving water use indoors:

1. Check all faucets in your home. Repair or replace any that are leaking.

2. Toilets are the most notorious of water wasters. Check your toilet for the obvious visible leaks, but more importantly, for the silent leaks that can waste hundreds of gallons a day. Put a few drops of food color in the toilet tank. If, after 15 or 20 minutes the color shows up in the bowl, YOU have a leak that should be repaired immediately.

3. Do not leave the faucet run while shaving, washing, rinsing vegetables, etc. A single sinkfull of water for these purposes can save gallons of water.

4. Install water saving showerheads and conservation

Appendix C

Copy of Questionnaire Sent to

Doylestown Sample

PENNSTATE

1855

Department of Agricultural Economics
and Rural Sociology
College of Agriculture

Weaver Budding
The Pennsylvania State University
University Park. PA 16802

Dear Doylestown Resident,

Citizens across Pennsylvania are becoming increasingly concerned about the quality of their drinking water supplies. Recent testing by the Pennsylvania Department of Environmental Resources has shown that many water supplies are not as pure as once believed. As a result, many communities are developing strategies for protecting their water supplies. In this survey, we are attempting to identify personal attitudes towards the quality of drinking water. The survey results can be helpful to community leaders as they manage and protect their water resources.

In order to better understand household reactions to water quality, we will need your help. Enclosed with this letter you will find a questionnaire that we would like you to complete. The focus of the questionnaire is on any activities you or your family take dealing with water use. The person most familiar with the daily activities that occur in your home (e.g., shopping, bill-paying, etc.) should answer the survey questions. Please complete the questionnaire and return it in the self-addressed stamped envelope.

Your answers to the questions will remain completely confidential. This project is being conducted by Penn State University and reports will only include statistical summaries of all responses. Your name and address were randomly drawn from a list of Doylestown residents that is available as public information and your responses to this study will not be available to others.

Of course, your participation in the survey is up to you. However, your participation is critical if the study's results are to be of use to us and to the citizens and community leaders of Pennsylvania. The study's conclusions will be shared with state and local organizations and government agencies involved with water resources management. If you would like a summary of the survey results, please write your name and address on the back of the return envelope.

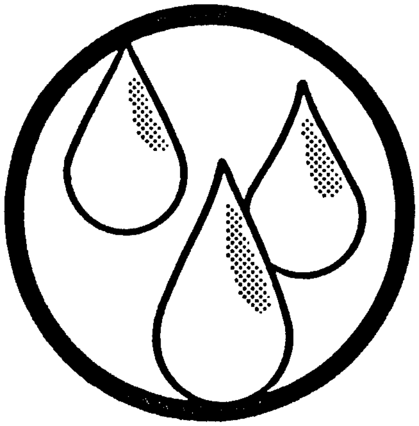
If you have any questions about any aspect of the survey, please call me collect at (814) 865-2561.

Thank you very much.

Sincerely,

Charles W. Abdalla

Charles W. Abdalla, Ph.D.
Assistant Professor of
Agricultural Economics



WATER QUALITY AND HOUSEHOLD ACTIVITY

SURVEY

DEPARTMENT OF AGRICULTURAL ECONOMICS
AND RURAL SOCIOLOGY
2 WEAVER BUILDING

PENNSTATE

This survey is part of a research project studying household views on water quality. Your responses will help us reach a better understanding of public opinion on the purity of water supplies. This study can help decision~makers to better manage our water resources. Your answers will remain completely confidential.

A. *CHEMICALS IN THE ENVIRONMENT.* *We* would like to begin by asking you a few questions l bout chemicals in our environment.

1. How would you rate your familiarity with chemical substances? (Please circle the number next to your answer.)

   1 Not familiar at all

   2 Somewhat familiar

   3 familiar

   4 Very familiar

2. In your opinion, how serious a problem are toxic chemicals in the environment (i.e., air, water or soil) within our society? (Circle the number next to your answer.)

   1 Not serious

   2 Somewhat serious

   3 Serious

   4 Very serious

   5 Don't know

B. *WATER QUALITY.* Next we have a set of questions concerning your views on your water supply and your household activities related to water use.

3. What is the source of the water supplied to your household? (Circle the number of your answer.)

   1 Doylestown Water Works

   2 Private well

   3 Don't know

   4 Other: ____________________

4. Are you aware of any problem(s) with your water supply?

   1 Yes (60 ON TO QUESTION 5)

   2 No ------------------------> **GO TO QUESTION 6**

5. Please describe any problem(s) that you are aware of with your water Supply .

6. Water supplies normally contain mall quantities of certain chemicals Which can cause cancer. How would you rate the cancer risk of drinking your water? (Circle the number of your answer.)

   1 Insignificant risk

   2 Not a serious risk

   3 Moderate risk

   4 Serious risk

   5 Very serious risk

7. Is anyone in your household taking any measures to avoid using the tap water supplied to your home? (Circle the number of your answer.)

   1 Yes (GO ON TO QUESTION 8)

   2 NO --------------------------> **GO TO QUESTION 13**

8. Is anyone in your household purchasing bottled water? (Circle the number of your answer.)

   1 Yes (GO ON TO QUESTION 9)

   2 No --------------------------> **GO TO QUESTION 10**

9. How many gallons of bottled water does your household use in an average week?

   ________ gallons per week

10. Does your household have any type of home water purification system? (Circle the number of your answer.)

   1 Yes (GO ON TO QUESTION 11)

   2 No --------------------------> **GO TO QUESTION 12**

11. How such money was spent for the purchase and installation of your home water purification system?

   ______ dollars

12. Please describe any other measures individuals in your household take to avoid using the tap water supplied to your home.

13. In your opinion, how much can you trust local officials to provide you with the facts about the quality of your water supply? (Circle the number of your answer.)

    1 You cannot trust them at all

    2 You cannot trust them very much

    3 You can trust them somewhat

    4 You can trust them a lot

14. In your opinion. how much can you trust state officials to provide you with the facts abut the quality of your water supply? (Circle the number of your answer.)

    1 You cannot trust them at all

    2 You cannot trust them very much

    3 You can trust them somewhat

    4 You can trust them a lot

15. What do you think is the chance that your water supply will be affected by any problem in the next few years? (Circle the number of your answer.)

    1 Very high chance

    2 High chance

    3 Moderate chance

    4 Low chance

    5 Very low chance

C. RESIDENCE. Next are a few questions about your residence.

16. Do you own or rent the place in which you live? (Circle the number of your answer.)

    1 Own (or buying)

    2 Rent

    3 Other: ____________________

17. How long have you lived in your current home?

    __________ years

D. FAMILY INFORMATION. We would like to ask a few questions about you and your family.

18. In what year were you born? __________

19. What is your sex? (Circle then number of your answer.)

    1 Male

    2 Female

20. On each of the lines below, please put the number of people in each age group who currently live in your household. Include yourself in the count. (If none for any category, write "0".)

    ____ Under 3 years old

    ____ 3-5 years old

    ____ 6- 17 years old

    ____ 18-24 years old

    ____ 25-44 years old

    ____ 5-64 years old

    ____ Over 64 years old

21. How far did you go In school? (Circle the number of your answer.)

    1 Never attended school

    2 Grade school

    3 Some high school

    4 Completed high school or equivalent

    5 Some college or vocational school

    6 Completed college

    7 Graduate or professions school (e.g. masters, Ph.D., law, medicine.)

22. What is your marital status? (Circle the number of your answer.)

1 Married

2 Not married

E. *HEALTH.* Next we would to ask a few questions concerning your health and possible health risks.

23. How would you rate your health at the present time? (Circle the number of your answer.)

1 Very poor

2 Poor

3 Fair

4 Good

5 Very Good

24. Do you get routine medical exams even though you are feeling well? (Circle the number of your answer.)

1 Yes

2 No

25. Do you currently smoke cigarettes? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 26)

2 No ----------------------------> **GO TO QUESTION 27**

26. On average, how many cigarettes a day do you smoke?

__________ cigarettes

27. How many times per week do you normally exercise? (Circle the number of your answer.)

1 Not at all

2 Once

3 Twice

4 Three to four times

5 Five or more tires

28 We are all exposed to a certain level of health risk from the environment around us, such as pollutants In the air we breathe. Sane of the chemicals in the environment Increase our risk of developing different types of cancer.

Suppose you were faced with the increased risks of developing cancer by the amounts listed below on the left. How serious of a health risk would you consider each of these increases in your risk of developing cancer? (Please circle a number on the right, one through five, following each increase in risk given in the left column.)

	Seriousness of health risk				
Increase in the Risk of Developing Cancer	Very Serious (5)	Serious (4)	Moderate (3)	Not Serious (2)	Insig-nificant (1)
1 in a billion	5	4	3	2	1
1 in 100 million	5	4	3	2	1
1 in 10 million	5	4	3	2	1
1 in a million	5	4	3	2	1
1 in 100,000	5	4	3	2	1
1 in 10.000	5	4	3	2	1
1 in 1.000	5	4	3	2	1
1 in 100	5	4	3	2	1
1 in 10	5	4	3	2	1

F. EMPLOYMENT. Lastly, we have a few questions about your current job.

29. At the present time. how would you describe employment status? (Circle the number of your answer.)

1 Employed full-time

2 Employed part-time

3 Not employed

30. Of the those categories below, which one (or, if necessary, two) best describes your current situation? (Check the appropriate answers.)

____ Employed by another

____ Self-employed

____ Homemaker

____ Student

____ Retired

____ Disabled

____ Unemployed, looking for work

____ Unemployed, not looking for work

31. If you are employed, what level of risk In the form of injury or adverse health effects do you feel you are exposed to while performing the duties of your job? (Circle the number of your answer.)

1 Insignificant risk

2 Not serious risk

3 Moderate risk

4 Serious risk

5 Very serious risk

32. What was the approximate total income of your household before taxes last year (1986)? (Please check the appropriate answer.)

____ Under $5,000

____ $5,000 to $7,499

____ $7,500 to $9,999

____ $10,000 to $14,999

____ $15,000 to $19,999

____ $20,000 to $24,999

____ $25,000 to $34,999

____ $35,000 to $49,999

____ $50,000 to $74,999

____ $75,000 or more

33. If we have not covered something that you feel is important, please use this space for your comments.

THANK YOU FOR TAKING THE TIME TO CONTRIBUTE TO THIS STUDY!

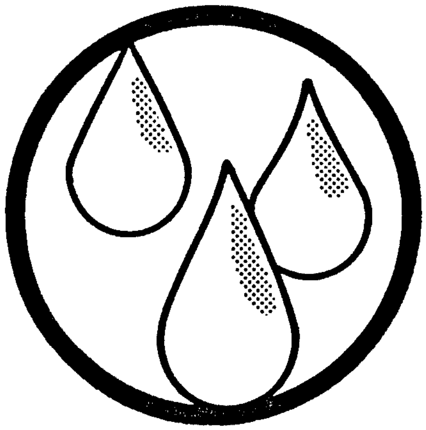
Please return the questionnaire in the enclosed stamped envelope
If you would like a summary of the study's findings, please
write your name and address on the back of the return envelope.

Water Quality and Household Activity Survey
2 Weaver Building
Penn State University
University Park, PA 16002

Appendix D

Copy of Questionnaire Sent to

Perkasie Sample



WATER QUALITY AND HOUSEHOLD ACTIVITY

SURVEY

DEPARTMENT OF AGRICULTURAL ECONOMICS
AND RURAL SOCIOLOGY
2 WEAVER BUILDING

PENNSTATE

This survey is part of a research project studying household views on water quality. Your responses will help us reach a better understanding of reactions to water quality problems. This study can help decision-makers to better manage our water resources. Your answers will remain completely confidential.

A. *CHEMICALS IN THE ENVIRONMENT.* We would like to begin by asking you a few questions about chemicals in our environment.

1. How would you rate your familiarity with chemical substances? (Please circle the number next to your answer.)

   1 Not familiar at all

   2 Somewhat familiar

   3 Familiar

   4 Very familiar

2. In your opinion, how serious a problem are toxic chemicals in the environment (i.e., air, water or soil) within our society? (Circle the number of your answer.)

   1 Not serious

   2 Somewhat serious

   3 Serious

   4 Very serious

   5 Don’t know

B. *WATER QUALITY.* The next questions concern the quality of your water supply and your household activities related to water use.

3. What is the source of the water supplied to your household? (Circle the number of your answer.)

   1 Perkasie Borough Water Authority (GO ON TO QUESTION 4)

   2 Don't know (GO ON TO QUESTION 4)

   3 Private well______________ **GO TO QUESTION 32**

4. In early 1983 the Pennsylvania Department of Environmental Resources (DER) found a chemical called trichloroethylene (TCE) in the water supply of the Perkasie Borough Water Authority. Prior to receiving this survey, were you aware of the finding of TCE in your water? (Circle the number of your answer.)

   1 Yes (GO ON TO QUESTION 5)

   2 No ______________ **GO TO QUESTION 32**

5. When did you first find out about the presence of TCE in your water supply?

   Month______________ Year______________

6. Prior to the announcement of TCE in your water supply, were you aware of any other problems(s) with your water supply? (Circle the number of your answer.)

   1 Yes (GO ON TO QUESTION 7)

   2 No ________ **GO TO QUESTION 8**

7. Please briefly describe the problem(s) that you were aware of before the announcement of TCE in your water supply.

8. Water supplies normally contain small quantities of certain chemicals which can cause cancer, How would you rate the cancer risks of drinking your water <u>before</u> the presence of TCE in the water supply? (Circle the number of your answer.)

   1 Insignificant risk

   2 Not a serious risk

   3 Moderate risk

   4 Serious risk

   5 Very serious risk

9. Overall, how much information have you received or obtained about the health risks of drinking or being exposed to water containing TCE? (Circle the number of your answer.)

   1 None

   2 Very little

   3 A fair amount

   4 A lot

10. Overall. how much information have you received or obtained about the act ions that could be taken by your household to reduce or avoid exposure to TCE? (Circle the number of your answer.)

   1 None

   2 Very little

   3 A fair amount

   4 A lot

11. Now much time did you and other members of your household spend locating information about the health risks of TCE or the actions that you could take to avoid exposure to TCE? (Circle the number of your answer.)

1 none

2 1 to 3 hours

3 4 to 6 hours

4 7 to 10 hours

5 11 to 15 hours

6 more than 15 hours

12. How much money did you and other members of your household spend locating information about the health risks of TCE or the actions that could be taken to avoid exposure to TCE? (Circle the number of your answer.)

1 none

2 1 to 10 dollars

3 11 to 20 dollars

4 21 to 50 dollars

5 51 to 100 dollars

6 more than 100 dollars

13. Prior to the announcement of TCE in your water supply, was anyone in your household taking any measures to avoid using the tap water supplied to your home? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 14)

2 No ————————> **GO TO QUESTION 18**

14. Prior to the announcement of TCE in your water supply, did anyone in your household purchase bottled water? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 15)

2 No ————————> **GO TO QUESTION 17**

15. As a result of the announcement of TCE in your water supply, did your household increase its purchases of bottled water? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 16)

2 No ————————> **GO TO QUESTION 17**

16. How many additional gal ions of bottled water did you purchase in an average week after the announcement of TCE in your water supply?

_________ additional gallons per week

17. Please describe any other measures individuals in your household took to avoid using tap water before the announcement of TCE in your water supply.

18. As a result of the finding of TCE in your water supply, did anyone in your household begin purchasing bottled water? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 19)

2 No ______________ **GO TO QUESTION 20**

19. After the announcement of TCE in your water supply. how many gallons of bottled water did your household purchase in an average week?

_____ gallons per week

20. As a result of the announcement of TCE in your water supply, did anyone in your household purchase any type of bane water purification system, or purchase additional equipment if you already had some type of purification system? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 21)

2 No ______________> **GO TO QUESTION 22**

21. HOW much money was spent on the home water purification system or additional equipment, including installation?

_____ dollars

22. As a result of the announcement of TCE in your water supply, did your household obtain water f ran a source other than your residence, such as haul ing water from a friend's home whose water does not contain TCE? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 23)

2 No ______________> **GO TO QUESTION 26**

23. How many trips per week did you or other members of your household make in an average week to obtain water?

_____ trips per week

24. How often was this trip for the sole purpose of hauling water? (Circle the number of your answer.)

1 Never

2 About one-quarter of the time

3 About one-half of the time

4 About three-quarters of the time

5 Always

25. What was the average round-trip distance of a trip to haul water?

______ miles round-trip distance

26. As a result of the finding of TCE in your water supply, did anyone in your household boil tap water to reduce the levels of TCE? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 27)

2 No ————> GO TO QUESTION 28

27. After the announcement of TCE in your water supply, how many gallons of water did your household boil in an average week?

______ gallons per week

28. Please describe any other measures individuals in your household took to reduce exposure to the TCE in your water supply.

29. At this time, are you or anyone in your household still taking measures to avoid exposure to TCE in your water supply? (Circle the number of your answer.)

1 Yes (60 ON TO QUESTION 30)

2 No ————> GO TO QUESTION 31

30. Please briefly list which measures you or members of your household are currently taking to avoid exposure to TCE.

31. Have you been notified by the Perkasie Borough Mater Authority that the levels of TCE in the water have been reduced below allowable levels? (Circle the number of your answer.)

    1. Yes

    2. No

32. In your opinion. how much can you trust local officials (such as the local water authority) to provide you with the facts about TCE in your water supply? (Circle the number of your answer.)

    1 You cannot trust than at all

    2 You cannot trust them very much

    3 You can trust them somewhat

    4 You can trust them a lot

33. In your opinion. how much can you trust state officials (such as the DER) to provide you with the facts about TCE in your water supply? (Circle the number of your answer.)

    1 You cannot trust them at all

    2 You cannot trust them very much

    3 You can trust them somewhat

    4 You can trust them a lot

34. What do you think is the chance that your water supply will be affected by other problems in the next few years? (Circle the number of your answer.)

    1 Very high chance

    2 High chance

    3 Moderate chance

    4 Low chance

    5 Very low chance

C. RESIDENCE. Next are a few questions about your residence.

35. Do you own or rent the place in which you live? (Circle the number of your answer.)

1 Own (or buying)

2 Rent

3 Other: ________________

36. How long have you lived in your current home?

________ years

D. FAMILY INFORMATION. We would like to ask a few questions about you and your family.

37. In what year were you born? ________

38. What is your sex? (Circle the number of your answer.)

1 Male

2 Female

39. On each of the lines below, please put the number of people in each age group who currently live in your household. Include yourself in the count. (If none for any category, write "0".)

____ Under 3 years old

____ 3 - 5 years old

____ 6 - 17 years old

____ 18 - 24 years old

____ 25 - 44 years old

____ 45 - 64 years old

____ Over 64 years old

40. How far did you go in school? (Circle the number of your answer.)

1 Never attended school

2 Grade school

3 Some high school

4 Completed high school or equivalent

5 Some college or vocational school

6 Completed college

7 Graduate or professional school (e.g. masters, Ph.D., law, medicine.)

41. What is your marital status? (Circle the number of your answer.)

1 Married

2 Not married

E. ***HEALTH.*** Next we would like to ask a few questions concerning your health and possible health risks.

42. How would you rate your health at the present tire? (Circle the number of your answer.)

1 Very poor

2 Poor

3 Fair

4 Good

5 Very Good

43. Do you get routine medical exams even though you are feeling well? (Circle the number of your answer.)

1 Yes

2 No

44. Do you currently smoke cigarettes? (Circle the number of your answer.)

1 Yes (GO ON TO QUESTION 45)

2 No ——————————> **GO TO QUESTION 46**

45. On average, how many cigarettes a day do you smoke?

__________ cigarettes

46. How many times per week do you normally exercise? (Circle the number of your answer.)

1 Not at all

2 Once

3 Twice

4 Three to four times

5 Five or more times

47. We are all exposed to a certain level of health risk from the environment around us. such as pollutants in the air we breathe. Some of the chemicals in the environment increase our risk of developing different types of cancer.

Suppose you were faced with the increased risks of developing cancer by the amounts listed below on the left. How serious of a health risk would you consider each of these increases in your risk of developing cancer? (Please circle a number on the right, one through five, following every increase in risk given in the left column

	Seriousness of health risk				
Increase in the Risk of Developing Cancer	Very Serious (5)	Serious (4)	Moderate (3)	Not Serious (2)	Insig- nificant (1)
1 in a billion	5	4	3	2	1
1 in 100 million	5	4	3	2	1
1 in 10 million	5	4	3	2	1
1 in a million	5	4	3	2	1
1 in 100,000	5	4	3	2	1
1 in 10.000	**5**	**4**	**3**	**2**	**1**
1 in 1.000	5	4	3	2	1
1 in 100	5	4	3	2	1
1 in 10	**5**	**4**	**3**	**2**	**1**

48. Now would you rate the risks of developing cancer associated with the levels of TCE in your water supply? (Circle the number of your answer.)

1 Insignificant

2 Not serious

3 Moderate

4 Serious

5 Very serious

F. EMPLOYMENT. Lastly, we have a few questions about your current job.

49. At the present time, how would you describe your employment status? (Circle the number of your answer.)

1 Employed full-time

2 Employed part-time

3 Not employed

50. Of the those categories below, which <u>one</u> (or. if necessary, <u>two</u> best describes your current situation? (Check the appropriate answers.)

____ Employed by another

____ Self-employed

____ Homemaker

____ Student

____ Retired

____ Disabled

____ Unemployed, looking for work

____ Unemployed, not looking for work

51. If you are employed, what level of risk in the form of injury or adverse health effects do you feel you are exposed to while performing the duties of your job? (Circle the number of your answer.)

1 Insignificant risk

2 Hot serious risk

3 Moderate risk

4 Serious risk

5 Very serious risk

6 Not applicable

52. What was the approximate total income of your household before taxes last year (1966)? (Please check the appropriate answer.)

____ Under $5,000

____ $5,000 to $7,499

____ $7,500 to $9,999

____ $10,000 to $14,999

____ $15,000 to $19,999

____ $20,000 to $24,999

____ $25,000 to $34,999

____ $35,000 to $49,999

____ $50,000 to $74,999

____ $75,000 or more

53. If we have not covered something that you feel is important, please use this space for your comments.

THANK YOU FOR TAKING THE TIME TO CONTRIBUTE TO THIS STUDY !

Please return the questionnaire in the enclosed stamped envelope. If you would like a summary of the study's findings. please write your name and address on the back of the return envelope.

Water Quality and Household Activity Survey
2 Weaver Building
Penn State University
University Park, PA 16802

Appendix E

Copy of Reminder Postcard

Sent to Perkasie and

Doylestown Samples

Last week I sent you a questionnaire concerned with water quality and household activities related to water use. If you have already returned the questionnaire, thank you for your prompt response. If you have not yet returned the questionnaire, please fill it out and return it. To obtain accurate information. it is important to the study that your views are represented.

If you did not receive a copy of the questionnaire or it was lost, please call me collect at (814) 865-2561. Another copy will be mailed to you.

Sincerely,

Charles Abdalla

Charles Abdalla
Department of Agricultural Economics
and Rural Sociology

Appendix F

Copy of Follow-up Telephone

Interview for Perkasie Sample

Perkasie Telephone Interview

Hello, my name is ____________ from Penn State University. We are contacting residents of Perkasie to find out about their activities related to household water use. Would you please help us by taking a couple of minutes to answer a few questions?

1. Is the water in your home supplied by the Perkasie Water Authority or do you have a private well?
   1 Perkasie Water Authority
   2 Private well
   3 Don't know

2. In early 1988 the Pennsylvania Department of Environmental resources found a chemical called TCE in the Perkasie Borough Water. Were you aware of the finding of TCE in the water?
   1 Yes (Go to #3)
   2 No (Go to #7)

3. Before finding out about TCE, was your household avoiding tap water use, such as by buying bottled water, using a water treatment system, boiling water or hauling water from a source outside your home?
   1 Yes (Go to #4)
   2 No (Go to #5)

4. Could you please list the measures you were taking?
   1 Bottled water
   2 Boiling water
   3 Treatment system
   4 Hauling water
   5 Other: ____

5. After finding out about TCE, did your household do anything differently concerning water use?
   1 Yes (Go to #6)
   2 No (Go to #7)

6. Could you please describe what your household did differently?
   1 Increase bottled water purchases
   2 Begin to purchase bottled water
   3 Boil water
   4 Treatment system
   5 Haul water
   6 Other: ____

7. That's all I would like to ask you, thank you for your time.

Appendix G

Copy of Follow-up Telephone

Interview for Doylestown Sample

Doylestown Telephone Interview

Hello, my name is ____________ from Penn State University. We are contacting residents of Doylestown to find out about their activities related to household water use. Would you please help us by taking a couple of minutes to answer a few questions?

1. Is the water in oyur home supplied by the Doylestown Water Works or do you have a private well?
   1 Doylestown Water Works
   2 Private well
   3 Don't know

2. Is your household avoiding tap water use, such as by buying bottled water, using a water treatment system, boiling water or hauling water from a source outside your home?
   1 Yes (Go to #3)
   2 No (Go to #4)

3. Could you please list the measures you are taking?
   1 Buying bottled water
   2 Boiling water
   3 Treatment system
   4 Hauling water
   5 Other:____

4. That's all I would like to ask you, thank you for your time.

Appendix H

Frequencies of Perkasie Variables Not Presented in the Text

Table H.1
Question 1: How would you rate your familiarity with chemical substances?

Category of response	Frequency	Percentage
1. Not familiar at all	170	21.4
2. Somewhat familiar	478	60.3
3. Familiar	100	12.6
4. Very Familiar	36	4.5
Missing Values	9	1.1
Total	793	100.0

Table H.2
Question 2: In your opinion, how serious a problem are toxic chemicals in the environment (i.e., air, water or soil) within our society?

Category of Response	Frequency	Percentage
1. Not serious	10	
2. Somewhat serious	91	1.3
3. Serious	270	34.0
4. Very serious	381	48.0
Missing Values	1	0.1
Total	793	100.0

Table H.3
Question 6: Prior to the announcement of TCE in your water supply, were you aware of any other problem(s) with your water supply?

Category of Response	Frequency	Percentage
1. Yes		18.4
2. No	242	79.6
Missing Values	6	2.0
Total	304	100.0

Table H.4
Question 9: Overall, how much information have you received or obtained about the health risks of drinking or being exposed to water containing TCE?

Category of Response	Frequency	Percentage
1. None	63	20.7
2. Very little	182	59.9
3. A fair amount	51	16.8
4. Alot	6	2.0
Missing Values	2	0.7
Total	304	100.0

Table H.5
Question 10: Overall, how much information have you received or obtained about the actions that could be taken by your household to reduce or avoid exposure to TCE?

Category of Response	Frequency	Percentage
1. None	114	37.5
2. Very Little	142	46.7
3. A fair amount	40	13.2
4. Alot	4	1.3
Missing Values	4	1.3
Total	304	100.0

Table H.6
Question 11: How much time did you and other members of your household spend locating information about the health risks of TCE or the actions that you could take to avoid exposure to TCE?

Category of Response	Frequency	Percentage
1. None	208	68.4
2. 1 to 3 hours	77	25.3
3. 4 to 6 hours	9	3.0
4. 7 to 10 hours	1	0.3
5. 11 to 15 hours	0	0.0
6. More than 15 hours	4	1.3
Missing Values	5	1.6
Total	304	100.0

Table H.7
Question 12: How much money did you and other members of your household spend locating information about the health risks of TCE or the actions that could be taken to avoid exposure to TCE?

Category of Response	Frequency	Percentage
1. None	273	90.0
2. 1 to 10 dollars	18	5.9
3. 11 to 20 dollars	2	0.7
3. 21 to 50 dollars	2	0.7
4. 51 to 100 dollars	1	0.3
5. More than 100 dollars	0	0.0
Missing Values	8	2.6
Total	304	100.0

Table H.8
Question 29: At this time, are you or anyone in your household still taking measures to avoid exposure to TCE in your water supply?

Category of Response	Frequency	Percentage
1. Yes	85	28.0
2. No	202	66.4
Missing Values	17	5.6
Total	304	100.0

Table H.9
Question 31: Have you been notified by the Perkasie Borough Water Authority that the levels of TCE have been reduced below allowable levels?

Category of Response	Frequency	Percentage
1. Yes	107	35.2
2. No	162	53.3
Missing Values	35	11.5
Total	304	100.0

Table H.10

Question 32: In your opinion, how much can you trust local officials (such as the local water authority) to provide you with the facts about TCE in your water supply?

Category of Response	Frequency	Percentage
1. Cannot trust them at all	84	12.0
2. Cannot trust them very much	180	25.7
3. Can trust them somewhat	335	47.9
4. Can trust them alot	82	11.7
Missing Values	19	2.7
Total	700	100.0

Table H.11

Question 33: In your opinion, how much can you trust state officials (such as the DER) to provide you with the facts about TCE in your water supply?

Category of Response	Frequency	Percentage
1. Cannot trust them at all	86	12.3
2. Cannot trust them very much	206	29.4
3. Can trust them somewhat	331	47.3
4. Can trust them alot	55	7.9
Missing Values	22	3.1
Total	700	100.0

Table H.12

Question 34: What do you think is the chance that your water supply will be affected by other problems in the next few years?

Category of Response	Frequency	Percentage
1. Very high chance	142	20.3
2. High chance	245	35.0
3. Moderate chance	232	33.1
4. Low chance	54	7.7
5. Very low chance	7	1.0
Missing Values	20	2.9
Total	700	100.0

Table H.13
Question 35: Do you own or rent the place in which you live?

Category of Response	Frequency	Percentage
1. Own (or buying)	534	76.3
2. Rent	160	22.9
Missing Values	6	0.9
Total	700	100.0

Table H.14
Question 38: What is your sex?

Category of Response	Frequency	Percentage
1. Male	372	53.1
2. Female	314	44.9
Missing Values	14	2.0
Total	700	100.0

Table H.15
Question 39: Number of individuals in household by age categories.

Age Category	None. Frequency (%)	One Person. Frequency (%)	Two People. Frequency (%)	Three People. Frequency (%)	Four People. Frequency (%)
1. Under 3	561 (81.7)	109 (15.9)	(2.5)	(0.0)	(0.0)
2. 3 to 5	574 (83.6)	92 (13.4)	21 (3.1)	0 (0.0)	0 (0.0)
3. 6 to 17	475 (69.1)	110 (16.0)	77 (11.2)	21 (3.1)	4 (0.6)
4. 18 to 24	576 (83.8)	78 (11.4)	30 (4.4)	2 (0.3)	1 (0.1)
5. 25 to 44	246 (35.8)	124 (18.0)	311 (45.3)	6 (0.9)	0 (0.0)
6. 45 to 64	525 (76.4)	81 (11.8)	81 (11.8)	0 (0.0)	0 (0.0)
7. Over 64	535 (77.9)	152 (22.1)	0 (0.0)	0 (0.0)	0 (0.0)

Table H.16
Question 40: How far did you go in school?

Category of Response	Frequency	Percentage
1. Never attended school	1	0.1
2. Grade school	24	3.4
3. Some high school	50	7.1
4. Completed high school	200	28.6
5. Some college or vocational school	201	28.7
6. Completed college	140	20.0
7. Graduate or professional school	73	10.4
Missing values	11	1.6
Total	700	100

Table H.17
Question 41: What is you marital status?

Category of Response	Frequency	Percentage
1. Married	520	74.3
2. Not married	170	24.3
Missing Values	10	1.4
Total	700	100.0

Table H.18
Question 42: How would you rate your health at the present time?

Category of Response	Frequency	Percentage
1. Very poor	4	0.6
2. Poor	14	2.0
3. Fair	83	11.9
4. Good	302	43.1
5. Very good	291	41.6
Missing Values	6	0.9
Total	700	100.0

Table H.19
Question 43: Do you get routine medical exams even though you are feeling well?

Category of Response	Frequency	Percentage
1. Yes	410	58.9
2. No	282	40.3
Missing Values	8	1.1
Total	700	100.0

Table H.20
Question 44: Do you currently smoke cigarettes?

Category of Response	Frequency	Percentage
1. Yes	137	19.6
2. No	555	79.3
Missing Values	8	1.1
Total	700	100.0

Table H.21
Question 46: How many times per week do you normally exercise?

Category of Response	Frequency	Percentage
1. Not at all	166	23.7
2. Once	85	12.1
3. Twice	182	26.0
4. Three to four times	157	22.4
5. Five or more times	96	13.7
Missing Values	14	2.0
Total	700	100.0

Table H.22
Question 47(a): How serious of a health risk would you consider a 1 in a billion increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	332	47.4
2. Not serious risk	86	12.3
3. Moderate risk	38	5.4
4. Serious risk	18	2.6
5. Very serious risk	36	5.1
Missing Values	190	27.1
Total	700	100.0

Table H.23
Question 47(b): How serious of a health risk would you consider a 1 in 100 million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	241	34.4
2. Not serious risk	147	21.0
3. Moderate risk	61	8.7
4. Serious risk	23	3.3
5. Very serious risk	38	5.4
Missing Values	190	27.1
Total	700	100.0

Table H.24
Question 47(c): How serious of a health risk would you consider a 1 in 10 million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	118	16.9
2. Not serious risk	192	27.4
3. Moderate risk	110	15.7
4. Serious risk	47	6.7
5. Very serious risk	41	5.9
Missing Values	192	27.4
Total	700	100.0

Table H.25
Question 47(d): How serious of a health risk would you consider a 1 in a million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	51	7.3
2. Not serious risk	162	23.1
3. Moderate risk	150	21.4
4. Serious risk	86	12.3
5. Very serious risk	59	8.4
Missing Values	192	27.4
Total	700	100.0

Table H.26
Question 47(e): How serious of a health risk would you consider a 1 in 100 thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	11	1.6
2. Not serious risk	65	9.3
3. Moderate risk	173	24.7
4. Serious risk	143	20.4
5. Very serious risk	114	16.3
Missing Values	194	27.7
Total	700	100.0

Table H.27
Question 47(e): How serious of a health risk would you consider a 1 in 100 thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	11	1.6
2. Not serious risk	65	9.3
3. Moderate risk	173	24.7
4. Serious risk	143	20.4
5. Very serious risk	114	16.3
Missing Values	194	27.7
Total	700	100.0

Table H.28
Question 47(f): How serious of a health risk would you consider a 1 in 10 thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	6	0.9
2. Not a serious risk	25	3.6
3. Moderate risk	99	14.1
4. Serious risk	175	25.0
5. Very serious risk	203	20.0
Missing Values	192	27.4
Total	700	100.0

Table H.29
Question 47(g): How serious of a health risk would you consider a 1 in a thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	2	0.3
2. Not a serious risk	13	1.9
3. Moderate risk	33	4.7
4. Serious risk	126	18.0
5. Very serious risk	336	48.0
Missing Values	190	27.1
Total	700	100.0

Table H.30
Question 47(h): How serious of a health risk would you consider a 1 in a hundred increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	1	0.1
2. Not a serious risk	9	1.3
3. Moderate risk	13	1.9
4. Serious risk	39	5.6
5. Very serious risk	449	64.1
Missing Values	189	27.0
Total	700	100.0

Table H.31

Question 47(i): How serious of a health risk would you consider a 1 in 10 increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	1	0.1
2. Not a serious risk	2	0.3
3. Moderate risk	12	1.7
4. Serious risk	12	1.7
5. Very serious risk	484	69.1
Missing Values	189	27.0
Total	700	100.0

Table H.32

Question 49: At the present time, how would you describe your employment status?

Category of Response	Frequency	Percentage
1. Employed full-time	419	59.9
2. Employed part-time	78	11.1
3. Not employed	189	27.0
Missing Values	14	2.0
Total	700	100.0

Table H.33

Question 51: If you are employed, what level of risk in the form of injury or adverse health effects do you feel you are exposed to while performing the duties of your job?

Category of Response	Frequency	Percentage
1. Insignificant risk	133	19.0
2. Not a serious risk	136	19.4
3. Moderate risk	167	23.9
4. Serious risk	47	6.7
5. Very serious risk	19	2.7
Missing Values	198	28.3
Total	700	100.0

Table H.34
Question 52: What was the approximate total income of your household before taxes last year (1988)?

Category of Response	Frequency	Percentage
1. Under $5,000	15	2.1
2. $5,000 to $7,499	10	1.4
3. $7,500 to $9,999	21	3.0
4. $10,000 to $14,999	40	5.7
5. $15,000 to $19,999	51	7.3
6. $20,000 to $24,999	55	7.9
7. $25,000 to $34,999	123	17.6
8. $35,000 to $49,999	162	23.1
9. $50,000 to $74,999	120	17.1
10. $75,000 or more	21	3.0
Missing Values	82	11.7
Total	700	100.0

Appendix I

Frequency of Doylestown Variables

Not Presented in the Text

Table I.1
Question 1: How would you rate your familiarity with chemical substances?

Category of Response	Frequency	Percentage
1. Not familiar at all	115	15.6
2. Somewhat familiar	417	56.6
3. Familiar	152	20.6
4. Very Familiar	45	6.1
Missing Values	8	1.1
Total	737	100.0

Table I.2
Question 2: In your opinion, how serious a problem are toxic chemicals in the environment (i.e., air, water or soil) within our society?

Category of Response	Frequency	Percentage
1. Not serious	11	1.5
2. Somewhat serious	73	9.9
3. Serious	241	32.7
4. Very serious	387	52.5
Missing Values	5	0.7
Total	737	100.0

Table 1.3
Question 13: In you opinion, how much can you trust local officials to provide you with the facts about the quality of your water supply?

Category of Response	Frequency	Percentage
1. Cannot trust them at all	57	7.7
2. Cannot trust them very much	158	21.4
3. Can trust them somewhat	402	54.5
4. Can trust them alot	104	14.1
Missing Values	16	2.2
Total	737	100.0

Table I.4
Question 14: In you opinion, how much can you trust state officials to provide you with the facts about the quality of your water supply?

Category of Response	Frequency	Percentage
1. Cannot trust them at all	86	11.7
2. Cannot trust them very much	199	27.0
3. Can trust them somewhat	387	52.5
4. Can trust them alot	48	6.5
Missing Values	17	2.3
Total	737	100.0

Table I.5
Question 15: What do you think is the chance that your water supply will be affected by any problems in the next few years?

Category of Response	Frequency	Percentage
1. Very high chance		13.4
2. High chance	166	22.5
3. Moderate chance	324	44.0
4. Low chance	117	15.9
5. Very low chance	22	3.0
Missing Values	9	1.2
Total	737	100.0

Table I.6
Question 16: Do you own or rent the place in which you live?

Category of Response	Frequency	Percentage
1. Own (or buying)	714	96.9
2. Rent	13	1.8
Missing Values	10	1.4
Total	737	100.0

Table I.7
Question 19: What is your sex?

Category of Response	Frequency	Percentage
1. Male	434	58.9
2. Female	286	38.8
Missing Values	17	2.3
Total	737	100.0

Table I.8 Number of individuals in household by age category.

Age Category	None. Frequency (%)	One Person. Frequency (%)	Two People. Frequency (%)	Three People. Frequency (%)	Four People. Frequency (%)
1. Under 3	660 (92.2)	47 Text	9 (1.3)	0 (0.0)	0 (0.0)
2. 3 to 5	657 (91.8)	55 (7.7)	4 (0.6)	0 (0.0)	0 (0.0)
3. 6 to 17	520 (72.6)	94 (13.1)	78 (10.9)	18 (2.5)	6 (0.8)
4. 18 to 24	595 (83.1)	92 (12.8)	26 (3.6)	3 (0.4)	0 (0.0)
5. 25 to 44	366 (51.1)	126 (17.6)	218 (30.4)	5 (0.7)	1 (0.1)
6. 45 to 64	403 (56.3)	135 (18.9)	177 (24.7)	1 (0.1)	0 (0.0)
7. Over 64	520 (72.6)	95 (13.3)	99 (13.8)	2 (0.3)	0 (0.0)

Table I.9
Question 21: How far did you go in school?

Category of Response	Frequency	Percentage
1. Never attended school	1	0.1
2. Grade school	16	2.2
3. Some high school	19	2.6
4. Completed high school	123	1637
5. Some college or vocational school	166	22.5
6. Completed college	192	26.1
7. Graduate or professional school	205	27.8
Missing Values	15	2.0
Total	737	100.0

Table I.10
Question 22: What is your marital status?

Category of Response	Frequency	Percentage
1. Married	560	76.0
2. Not married	162	22.0
Missing Values	15	2.0
Total	737	100.0

Table I.11
Question 23: How would you rate your health at the present time?

Category of Response	Frequency	Percentage
1. Very poor	3	0.4
2. Poor	6	0.8
3. Fair	83	11.3
4. Good	321	43.6
5. Very good	310	42.1
Missing Values	14	1.9
Total	737	100.0

Table I.12
Question 24: Do you get routine medical exams even though you are feeling well?

Category of Response	Frequency	Percentage
1. Yes	503	68.2
2. No	219	29.7
Missing Values	15	2.0
Total	737	100.0

Table I.13
Question 25: Do you currently smoke cigarettes?

Category of Response	Frequency	Percentage
1. Yes	111	15.1
2. No	610	82.8
Missing Values	16	2.2
Total	737	100.0

Table I.14
Question 27: How many times per week do you normally exercise?

Category of Response	Frequency	Percentage
1. Not at all	142	19.3
2. Once	73	9.9
3. Twice	152	20.6
4. Three to four times	220	29.9
5. Five or more times	118	16.0
Missing Values	32	4.3
Total	737	100.0

Table I.15
Question 28(a): How serious of a health risk would you consider a 1 in a billion increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	387	52.5
2. Not a serious risk	74	10.0
3. Moderate risk	40	5.4
4. Serious risk	19	2.6
5. Very serious risk	15	2.0
Missing Values	202	27.4
Total	737	100.0

Table I.16
Question 28(b): How serious of a health risk would you consider a 1 in 100 million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	272	36.9
2. Not a serious risk	158	21.4
3. Moderate risk	63	8.5
4. Serious risk	25	3.4
5. Very serious risk	17	2.3
Missing Values	202	27.4
Total	737	100.0

Table I.17
Question 28(c): How serious of a health risk would you consider a 1 in 10 million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	168	22.8
2. Not a serious risk	167	22.7
3. Moderate risk	129	17.5
4. Serious risk	45	6.1
5. Very serious risk	26	3.5
Missing Values	202	27.4
Total	737	100.0

Table I.18
Question 28(d): How serious of a health risk would you consider a 1 in a million increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	80	10.9
2. Not a serious risk	131	17.8
3. Moderate risk	174	23.6
4. Serious risk	107	14.5
5. Very serious risk	42	5.7
Missing Values	203	27.5
Total	737	100.0

Table I.19
Question 28(e): How serious of a health risk would you consider a 1 in 100 thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	24	3.3
2. Not a serious risk	71	9.6
3. Moderate risk	158	21.4
4. Serious risk	155	21.0
5. Very serious risk	127	17.2
Missing Values	202	27.4
Total	737	100.0

Table I.20
Question 28(f): How serious of a health risk would you consider a 1 in 10 thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	10	1.4
2. Not a serious risk	22	3.0
3. Moderate risk	99	13.4
4. Serious risk	176	23.9
5. Very serious risk	228	30.9
Missing Values	202	27.4
Total	737	100.0

Table I.21
Question 28(g): How serious of a health risk would you consider a 1 in a thousand increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	4	0.5
2. Not a serious risk	7	0.9
3. Moderate risk	34	4.6
4. Serious risk	112	15.2
5. Very serious risk	378	51.3
Missing Values	202	27.4
Total	737	100.0

Table I.22
Question 28(h): How serious of a health risk would you consider a 1 in a hundred increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	2	0.3
2. Not a serious risk	4	0.5
3. Moderate risk	11	1.5
4. Serious risk	41	5.6
5. Very serious risk	477	64.7
Missing Values	202	27.4
Total	737	100.0

Table I.23
Question 28(i): How serious of a health risk would you consider a 1 in 10 increase in your risk of developing cancer?

Category of Response	Frequency	Percentage
1. Insignificant risk	2	0.3
2. Not a serious risk	4	0.5
3. Moderate risk	4	0.5
4. Serious risk	13	1.8
5. Very serious risk	512	69.5
Missing Values	202	27.4
Total	737	100.0

Table I.24
Question 29: At the present time, how would you describe your employment status?

Category of Response	Frequency	Percentage
1. Employed full-time	428	58.1
2. Employed part-time	97	13.2
3. Not employed	198	26.9
Missing Values	14	1.0
Total	737	100.0

Table I.25
Question 31: If you are employed, what level of risk in the form of injury or adverse health effects do you feel you are exposed to while performing the duties of your job?

Category of Response	Frequency	Percentage
1. Insignificant risk	244	33.1
2. Not a serious risk	127	17.2
3. Moderate risk	135	18.3
4. Serious risk	25	3.4
5. Very serious risk	14	1.9
Missing Values	192	26.1
Total	737	100.0

Table I.26
Question 32: What was the approximate total income of your household before taxes last year (1988)?

Category of Response	Frequency	Percentage
1. Under $5,000	4	0.5
2. $5,000 to $7,499	9	1.2
3. $7,500 to $9,999	7	0.9
4. $10,000 to $14,999	26	3.5
5. $15,000 to $19,999	27	3.7
6. $20,000 to $24,999	49	6.6
7. $25,000 to $34,999	90	12.2
8. $35,000 to $49,999	143	19.4
9. $50,000 to $74,999	191	25.9
10. $75,000 or more	111	15.1
Missing Values	80	10.9
Total	737	100.0

Appendix J

Summary of Two-Stage Least

Squares Application

The application of ordinary least-squares (OLS) indicated that risk perception significantly influenced averting expenditures in both communities. However, risk perception can be hypothesized to be dependent upon some of the same independent variables as averting expenditures. For example, trust in state and local officials may have a significant influence upon risk perception and averting expenditures. The implications of such a situation are presented below.

Define a regression model as:

$$Y = \beta_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon. \tag{1}$$

Assume one of the independent variables (X_n) can be specified as a dependent variable in another regression model as:

$$X_n = \gamma_1 + \gamma_2 Z_2 + \ldots + \gamma_m Z_m + \varepsilon' \tag{2}$$

where some of the independent variables are similar to those included in Equation 1. Using OLS to estimate Equation 1 will result in a correlation between X_n and the error term (ε) (Hanushek and Jackson, 1977). This violates the assumption of the OLS model that the error term is uncorrelated with each independent variable. As a result, the parameter estimate associated with X_n will be biased and inconsistent (Pindyck and Rubinfeld, 1981).

Unbiased and consistent results can be obtained in this situation by applying two-stage least-squares (2SLS) (Pindyck and Rubinfeld, 1981). The first stage uses OLS techniques to estimate Equation 2. The predicted values of X_n are then used as independent variables in Equation 1 instead of the actual values of X_n Equation 1 is then estimated using OLS. While 2SLS estimates are unbiased and consistent, inefficient results may occur using 2SLS (Kmenta, 1971). In other words, a 2SLS approach may indicate that some independent variables are not significantly related to the dependent variable which should be significant.

Regression models were run for both communities using 2SLS. The 2SLS results for the Doylestown sample are presented in Table J.1. The dependent variable considered in the first stage was D_RISK. The first stage model was constructed by referring to the Pearson correlation matrix (similar to the procedure described in section 5.2). The predicted value of D_RISK was then used as an independent variable in the second stage regressions. The dependent variable was estimated yearly averting expenditures. The predicted value of D_RISK was statistically significant at the 0.10 level in the second stage regression model.

The 2SLS regression results for the Perkasie sample are presented in Table J.2. The dependent variable was P_TCE in the first stage regression. The dependent variable in the second stage was the estimated averting expenditures associated with TCE contamination. The predicted value of P_TCE was statistically significant at the 0.05 level.

Table J.1 Doylestown Two-Stage Least Squares Regression Results

First Stage (Dependent Variable - D_RISK)
Number of Observations: 637
F-Value: 28.067 (entire model is significant at the 0.01 level)
R-Squared Value: 0.2091 Adjusted R-Squared Value: 0.2016

Variable	Parameter Estimate	T-Value
Intercept	3.166	9.376***
TRUST	-0.170	-7.519***
SERIOUS	0.270	6.256***
SCHOOL	-0.103	-3.695***
FUTURE	-0.136	-3. 129***
GENDER	0.007	0.114
AGE	-0.003	-1.260

Second Stage (Dependent Variable - Estimated Yearly Averting Expenditures)
Number of Observations: 600
F-Value: 8.356 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.1432 Adjusted R-Squared Value: 0.1261

Variable	Parameter Estimate	T-Value
Intercept	-445.249	-1.950%
HOME	101.719	3.838***
FAMILIAR	10.685	2. 330**
INCOME	20.966	2.501**
INFANT	16.030	2. 159**
D_RISK (Predicted)	118.826	1. 778*
SCHOOL	14.301	1.910*
D PROB	-2.350	-0.095
FUTURE	1.670	0.211
CHILD	16.464	1.290
SERIOUS	-24.480	-1.467
TRUST	16.423	1.459
AGE	0.064	0.198
D_RATE	1.734	0.652
EXERCISE	4.601	1.038

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level
* - indicates statistical significance at the 0.10 level

Table J.2 Perkasie Two-Stage Least Squares Regression Results

First Stage (Dependent Variable - P_TCE)
Number of Observations: 251
F-Value: 12.686 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.2613 Adjusted R-Squared Value: 0.2407

Variable	Parameter Estimate	T-Value
Intercept	0.697	1.160
SERIOUS	0.351	4.202***
GENDER	0.432	3.667***
TRUSTLOC	-0.280	-3.465***
FUTURE	0.181	2. 079**
HOME	0.193	1.041
P_OTHER	0.111	0.719
AGE	0.005	1.271

Second Stage (Dependent Variable - Estimated Household Expenditures Resulting from TCE Contamination)
Number of Observations: 267
F-Value: 6.192 (Entire model is significant at the 0.01 level)
R-Squared Value: 0.0849 Adjusted R-Squared Value: 0.0712

Variable	Parameter Estimate	T-Value
Intercept	-53.492	-1.197
INFANT	52.439	2.629***
P_TCE (Predicted)	31.486	2. 028**
P_OTHER	41.426	1. 996**
CHILD	24.624	1.506

*** - indicates statistical significance at the 0.01 level
** - indicates statistical significance at the 0.05 level

The trust variables, FUTURE and SERIOUS significantly influenced qualitative risk perception in both first stage models. The Perkasie first stage model indicated that males perceived the risk of TCE to be higher. The second stage results indicated that the predicted values of risk perception were positively related to averting expenditures but the significance of this relationship was lower than the OLS results displayed. The parameter estimate of P_TCE was 24.779 using OLS and 31.486 using 2SLS. This suggests that the bias associated with OLS was probably small. The bias appeared to be larger in the Doylestown sample since the parameter estimate of D_RISK was 10.513 using OLS and 118.826 using 2SLS. Also, the R^2 values of the 2SLS models were slightly less than those of the OLS models.

A tradeoff exists between 2SLS and OLS. Biased and inconsistent results may occur using OLS but less efficient results are likely to occur using 2SLS. Applying both techniques to the data indicated the bias associated with OLS affected the magnitude but not the sign of the parameter estimates. However, the loss of efficiency associated with the 2SLS approach may have affected the significance level of the qualitative risk variables.

The survey instrument used in this study was not designed to determine the factors influencing risk perceptions. The inefficiency associated with 2SLS could be decreased by eliciting more information concerning the variables influencing risk perceptions.